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CONTENTS OF VOLUME XIII.

NUMBER LXXIII.

Page

Art. I.—Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service, and from other sources; by Elias Loomis, ... 1

II.—On some Points in Connection with Vegetation; by J. H. Gilbert, ... 20

III.—Observations on a property of the Retina, first noticed by Tait; by Ogden N. Rood, ... 32

IV.—On grains of Metallic Iron in Dolerytes from New Hampshire; by George W. Hawes, ... 33

V.—On certain Phenomena of Binocular Vision; by Francis E. Nipher, ... 35

VI.—Notes on the Vespertine Strata of Virginia and West Virginia; by William M. Fontaine, ... 37

VII.—On the production of Transparent Metallic Film by the Electrical Discharge in exhausted tubes; by Arthur W. Wright, ... 49

Appendix.—Photographs of the Spectra of Venus and α Lyræ. Note by Prof. Henry Draper, ... 3d page of cover.

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—So-called Crystallized Boron, Hampe, 55.—Constitution of the Phosphates, Berthelot and Louguinine: Critical Point of Liquid Carbon Dioxide, Hartley, 56.—Spectra of Indium, Clayden and Heycock: Preparation of Hydroquinone, Weselsky and Schuler, 57.—Gelsemium sempervirens, Sonnenschein: Kurze allgemeine Einleitung zu den aromatischen Nitro-verbindungen von Peter Townsend Austen: Mariotte's Law, 58.—Physical Properties of Gallium: Plasticity of Ice, Prof. Bianconi, 59.—Velocity of Electricity, Dr. Sabine. 60.—Chemistry and Physics in America, Prof. John W. Draper, 61.—Prof. Draper's researches, 67.

Geology and Mineralogy.—Explorations made under the direction of F. V. Hayden, in 1876, 68.—Geological Survey of Kentucky, 74.—The American Bison, living and extinct, J. A. Allen: Second Geological Survey of Pennsylvania, 75.—Glacial Phenomena of North America, Prof. Otto Torell, 76.—Note on the Glacial era, J. D. Dana, 79.—Monograph of American Trilobites, A. W. Vogdes, 80.—Outline of the Geology of Canada, E. J. Chapman: Origin of Forest and Prairie regions: Great Ice Age and its relation to the Antiquity of Man, James Geikie, 81.

Botany and Zoology.—Date of Publication of Elliott's Botany of South Carolina and Georgia, 81.—Homogone and Heterogone (or Homogonous and Heterogonous) Flowers, 82.—Geographical Statistics of the European Flora, 83.—Wild Flowers of America, Isaac Sprague, 84.—Report upon Geographical and Geological Explorations and Surveys, west of the One-hundredth Meridian, Lieut. Geo. M. Wheeler, 85.

Astronomy.—The secular change of Magnetic declination in the United States, and other parts of North America, Charles A. Schott, 85.—Investigation of Corrections to Hansen's Tables of the Moon, S. Newcomb: Knobel's Reference Catalogue of Astronomical Papers and Researches, 87.

Miscellaneous Scientific Intelligence.—Notes on Assaying and Assay-Schemes, Pierre de Peyster Ricketts: Alcohol Strength of Australian Wines, 87.—*Obituary.*—F. B. Meek: David Forbes, 88.

NUMBER LXXIV.

Page

ART. VIII.—Astronomical Observations on the Atmosphere of the Rocky Mountains, made at elevations of from 4,500 to 11,000 feet, in Utah and Wyoming Territories and Colorado; by **Henry Draper**, ... 89

IX.—Photographs of the Spectra of Venus and α Lyræ; by **Henry Draper**, ... 95

X.—On Dinitroparadibrombenzols and their Derivatives; by **Peter Townsend Austen**, ... 95

XI.—On some Points in connection with Vegetation; by **J. H. Gilbert**, ... 99

XII.—Orbit of the planet Urda (167); by **C. H. F. Peters**, 112

XIII.—Principles of Compensation in Chronometers; by **J. B. James**, ... 113

XIV.—Notes on the Vespertine Strata of Virginia and West Virginia; by **William M. Fontaine**, ... 115

XV.—On the Chemical composition of the flesh of Hippoglossus Americanus; by **R. H. Chittenden**, ... 123

XVI.—Notice of Darwin on the Effects of Cross- and Self-Fertilization in the Vegetable Kingdom; by **Asa Gray**, 125

XVII.—Note on Microdiscus speciosus; by **S. W. Ford**, ... 141

XVIII.—On Water Courses upon Long Island; by **Elias Lewis, Jr.**, ... 142

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Purification of Hydrogen gas, 146.—Hypovanadic Oxide and its Compounds, **Crow**: Plato- and Diplato-nitrites, **Nilson**, 147.—Behavior of Palladium in the Alcohol flame, **Wöhler**: Two new Dichlornaphthalenes: Emodin from the bark of Rhamnus frangula, **Liebermann** and **Waldstein**, 148.—Phthaleins of Tertiary aromatic bases, **Fischer**: Standard Meter, **M. G. Matthey**, 149.—Films of Water, **Taylor**: Fog-Signals, **Henry**, 151.—The Siphon Recorder and Automatic Curb-sender, 152.

Geology and Mineralogy.—Report on the Transportation route along the Wisconsin and Fox Rivers, Wisconsin, **G. K. Warren**, 152.—Ice work now going on in Newfoundland, **S. Milne**: Glaciation of the Shetland Isles, **John Horne**, 155.—Note on the relations of Balanus Estrellanus of California Miocene, **T. A. Conrad**, 156.—Stromatopora: Geological Survey of Victoria, **R. Brough Smyth**: Fossil Elephant in Washington Territory, **Wm. O. Matzger**: Mesozoic Fossils, vol. i, **J. F. Whiteaves**: Miocene in Southern New Guinea, **C. S. Wilkinson**, 157.—Recherches sur les Fossiles Paléozoiques de la Nouvelle Galles du Sud (Australie), **de Koninck**, 158.—Syenitic mountains of Ditro, etc., **G. vom Rath**: "Greenstones" of Western Cornwall, **J. A. Phillips**, 159.—Petrographische Studien an den Melaphyrgesteinen Böhmens, **E. Boricky**: Minerals of New South Wales, **A. Liversidge**: Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland: Prospectus of the "Zeitschrift für Krystallographie und Mineralogie," 162.

Botany and Zoology.—Ulothrix zonata, **Arnold Dodel**, 163.—De Copulatione Microzoosporarum Enteromorphæ compressæ, **J. E. Areschoug**: Wyville Thomson on some of the Echinoderms of the "Porcupine" and "Challenger" Expeditions, 164.—Zoology of the Challenger Expedition, **A. Agassiz**, 165.—Rate of Growth of Corals: Bulletin of the Nuttall Ornithological Club, 166.

Astronomy.—Meteor of Dec. 21st, 1876, 166.

Miscellaneous Scientific Intelligence.—Bressa Prize, of the Turin Academy of Sciences, 167.—Annual Report of the Board of Regents of the Smithsonian Institution for 1875: Theory of Sound in its relation to Music, **Pietro Blaserna**, 168.

NUMBER LXXV.

Page
Art. XIX.—In Memoriam.—Fielding Bradford Meek, ... 169
XX.—Notes on the Age of the Rocky Mountains in Colorado; by A. C. Peale, ... 172
XXI.—On some Points in connection with Vegetation; by J. H. Gilbert, ... 181
XXII.—Apparatus for quantitative Fat-extraction; Composition of the Sweet Potato; Composition of Maize Fodder; by S. W. Johnson, ... 196
XXIII.—Meteoric Stone of Rochester, Fulton Co., Indiana; by Charles Upham Shepard, ... 207
XXIV.—Examination of the Waconda Meteoric Stone, Bates County Meteoric Iron and Rockingham County Meteoric Iron; by J. Lawrence Smith, ... 211
XXV.—Certain features of the Valleys or Water-courses of Southern Long Island; by Elias Lewis, ... 215

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—On Rock-crystal Balance-beams, Thermometers, and graduated Circles, Stein, 216.—Evolution of Hydrogen at both Electrodes in Electrolysis, Elsaesser: Relation of the Molecular weights of Chemical substances to their Heat-absorbing power, Aymonnet: On the Existence of Solid Particles of Carbon in Luminous Flames, Heumann, 217.—Alcohol from the leaves of the Sugar-beet, Pierre: On the Detection of ordinary Alcohol in Wood Spirit, Berthelot: Synthesis of Allantoin, Grimaux, 218.—Rhodein, a new test for Aniline, Jacquemin: Sensitive Flames, R. H. Ridout, 219.—Theory of Luminous Flames, Karl Hinmann: Influence of Pressure on Combustion, M. Wartha, 220.—Large Induction Coil, Wm. Spottiswoode, 221.—Lectures on some Recent Advances in Physical Science, with a Special Lecture on Force, P. G. Tait, 222.

Geology and Mineralogy.—Grand'eury on the Carboniferous Flora, 222.—Memoirs of the Geological Survey of Kentucky, N. S. Shaler, 226.—Report of a Reconnaisance from Carroll, Montana Territory, Wm. Ludlow, 228.—The Yellowstone National Park and the Mountain regions of portions of Idaho, Nevada, Colorado and Utah, F. V. Hayden, 229.—Report on the Geological Survey of Alabama, Eugene A. Smith: Annual Report of Progress and Results of the Wisconsin Geological Survey, T. C. Chamberlin, 230.—Report of the State Geologist of New Jersey, G. H. Cook: Salt Region of Goderich, Canada, 231.—Glaciers in the Urals during the Glacial Era, 232.—Trilobites, C. D. Walcott: Geology and Paleontology of the Argentine Republic, H. B. Geinitz, 233.—Mémoire sur les Caractères Minéralogiques et Stratigraphiques des Roches, etc., Ch. De la Vallée Poussin et A. Renard: Note on new localities of the Columbic acid minerals, and two new Columbates, J. Lawrence Smith: Bulletin of the Bussey Institution, 234.—Heights on Long Island. 235.

Botany and Zoology.—Dextrorse and Sinistrorse, 236.—Botanical Necrology of 1876, 237.—Mistletoe, 238.—Observations on Rhizopods, Leidy, 239.—Habits of Formica rufa, McCook, 241.—The Rhynchophora of America, north of Mèxico, John L. LeConte: A new Echidna from New Guinea, 242.

Astronomy.—A New Planet, C. H. F. Peters: Instruments and Publications of the U. S. Naval Observatory, 242.—Note of the recent fall of three Meteoric Stones, J. Lawrence Smith, 243.

Miscellaneous Scientific Intelligence.—Topographical Survey of the State of New York: Tour of the Great Lakes: Elements of Physics, Neil Arnott: Metric System, 244.—Illinois Museum of Natural History: Huronian rocks of the Lake Superior region: Third Annual Report of the Commissioner of Agriculture of the State of Georgia: The Applications of Physical Forces, Amedée Guillemin, 245.

Obituary.—Rear Admiral Charles Henry Davis: Rear Admiral Charles Wilkes: Alfred Smee: J. C. Poggendorff, 246.

NUMBER LXXVI.

Page

Art. XXVI.—On the Sensation of Color; by C. S. Peirce, .. 247

XXVII.—Note on the Binocular Phenomena observed by Professor Nipher; by J. LeConte, ... 252

XXVIII.—Revision of the genus *Belemnocrinus;* by Chas. Wachsmuth and Frank Springer, ... 253

XXIX.—Thorpe's and Bunsen's methods for the Estimation of Nitrogen in Nitrates; by S. W. Johnson, ... 260

XXX.—Westfield during the Champlain Period; by J. S. Diller, ... 262

XXX*bis*.—New Embryonic Forms of Trilobites; by S. W. Ford. With a plate, ... 265

XXXI.—The Winds of the Globe; or the Laws of Atmospheric circulation over the surface of the Earth, ... 273

XXXII.—On some Nitro-derivatives of Diphenylamine; by P. T. Austen, ... 279

XXXIII.—Note on Mineral Analysis; Note upon some Fluorides; Note on Molecular Volumes; by F. W. Clarke, 290

XXXIV.—On the identity of the so-called Peganite of Arkansas with the Variscite of Breithaupt and Callainite of Damour; by A. H. Chester, ... 295

XXXV.—On a fibrous variety of Sepiolite from Utah; by A. H. Chester, ... 296

XXXVI.—On Dr. Peale's Notes on the Age of the Rocky Mountains in Colorado; by J. J. Stevenson, ... 297

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Velocity of Chemical Reactions, Boguski and Kajander. 299.—Equivalence of Nitrogen, Ladenburg and Struve: Action of fuming Nitric Acid on Coal Gas, Akestorides: Oxidized platinic sulphide, E. v. Meyer, 301.—Preparation of Glycollic acid by reduction of oxalic acid, Crommydis: Decomposition of the Oil of Turpentine at high Temperatures, Schultz: Constituents of Beech-wood Tar-creosote, Tiemann and Mendelsohn, 302.—Measurement of High Pressures, M. L. Cailletet: Diathermaneity of Metals and Paper, M. Aymonnet, 303.—Increase of Weight by Combustion, M. V. Meyer: Absorption of Light, M. Lippich: Lippmann's Electrometer, 304.—Entwickelung der theoretischen Ansichten über die gepaarten Schwefelverbindungen, von G. A. Smyth, 305.

Geology and Mineralogy.—Age of the Crystalline Rocks of Wisconsin, R. Irving, 307.—Microscopical Petrography, F. Zirkel, 309.—Connecticut Valley Helderberg, C. H. Hitchcock, 313.—On Geological Time, T. M. Reade, 314.—The Carboniferous and Permian a continuous formation in Bohemia: Revue de Géologie pour les Années 1874–75, M. Delesse et M. de Lapparent, 315.—A fossil Saurian Vertebra from the Arctic Regions, A. L. Adams: Fossil Vertebrates from the Fort Union beds of Montana, E. D. Cope, 316.—A Text-book of Mineralogy, with an extended Treatise on Crystallography and Physical Mineralogy, E. S. Dana: Second Preliminary Report on the Mineralogy of Pennsylvania, F. A. Genth, 317.—Brief Notices of some newly described minerals, 318.—Zeitschrift für Krystallographie und Mineralogie: Ueber der inneren Zusammenhang der verschiedenen Krystallgestallten des Kalkspaths, F. Scharff, 319.—Chemistry and Composition of the Porcelain and Porcelain-rocks of Japan, Wurtz, 320.

Botany and Zoology.—Dictionnaire de Botanique, M. H. Baillon: Flora Fossilis Arctica; Die Fossile Flora der Polarländer, O. Heer, 320.—Proceedings and Transactions of the Nova Scotia Institute of Natural Science: Lady Smith, 321.—Joseph de Notaris: Recent Papers on Fungi: Destruction of Forest Trees by Mistletoe, E. S. Crozier, 322.—Median and Paired Fins, a contribution to the history of Vertebrate Limbs, J. K. Thacher, 323.

Astronomy.—Elements of Borelly's Comet, A. N. SKINNER, 323.—Photographic Spectra of Stars, W. HUGGINS, 324.—Satellites of Jupiter, D. P. TODD, 325.

Miscellaneous Scientific Intelligence.—Geological Society of London: Bulletin of the Buffalo Society of Natural Sciences, 325.—California State Geological Society: Meteorology of Golden, Colorado: American Microscopical Society: Structure of Precious Opal: Shoal in the Atlantic, 326.—*Obituary.*—Wolfgang Sartorius von Waltershausen, 326.

NUMBER LXXVII.

Page

ART. XXXVII.—On Vortex Rings in Liquids; by J. TROWBRIDGE, ... 327

XXXVIII.—An account of the Discoveries in Vermont Geology of the Rev. AUGUSTUS WING; by JAMES D. DANA, .. 332

XXXIX.—Notes on the History of *Helianthus tuberosus*, the so-called Jerusalem Artichoke; by J. HAMMOND TRUMBULL and ASA GRAY, ... 347

XL.—A new Investigation of one of the Laws of Friction; by A. S. KIMBALL, ... 353

XLI.—Examination of American Columbic Acid Minerals; by J. LAWRENCE SMITH, ... 359

XLII.—On the Sensitiveness to Light of various Salts of Silver; by M. CAREY LEA, ... 369

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Chemical Actions of the Silent Electric Discharge, BERTHELOT, 371.—Is Nitrogen oxidized by Ozone in the presence of Alkalies? BERTHELOT, 372.—Equivalence of Nitrogen, VICTOR MEYER: A new metallic element, Neptunium, HERMANN, 373.—Phosphorescence of Organic Liquids, RADZISZEWSKI: Melezitose, VILLIERS, 374.—Tri-substitution derivatives of Benzol, E. F. SMITH, 375.—Kinetic Theory of Gases, M. BOLTZMANN: Vowel "Clang," M. AUERBACH, 378.—Ultra Red Spectrum, M. E. BECQUEREL, 379.—Fluorescence, M. LOMMEL: Equilibrium of heterogeneous substances, J. WILLARD GIBBS, 380.

Geology and Mineralogy.—The Lœss of the Rhine and Danube, T. BELT, 383.—Thickness of the Palæozoic rocks of Central Pennsylvania, 384.—Lower Helderberg rocks of Port Jervis, N. Y., S. T. BARRETT, 385.—Geological and Geographical Survey of the Territories, 387.—Note on the Criticism of Prof. Stevenson, A. C. PEALE, 388.—American Palæozoic Fossils: Palæontographica: Analyses of Japanese Porcelain-rocks, H. WURTZ, 389.—Hermannolite of Shepard, and Samarskite of North Carolina, Prof. DELAFONTAINE, 390.

Botany and Zoology.—Right-handed and Left-handed Relations in Space: Observations sur l' enroulement des Vrilles, DECANDOLLE, 391.—Date of the parts of Elliott's Botany: Onion-Smut, W. G. FARLOW, 392.—Botanical Instruction at Harvard University, 393.—Classification and Terminology in Monocotyledons, 394.—The Various Contrivances by which Orchids are fertilized by Insects, 395.

Astronomy.—The New Star in Cygnus, 395.—Planets recently discovered, 397.—Publications of the Private Observatory of Lord Lindsay, Dun Echt (Aberdeen), 398.—La Luce Zodiacale, sue Leggi e Teoria Cosmico-Atmospherica, dedotte dalle Osservazione di G. Jones: Comets in 1877, 399.—Observations of Comets 1877*b*. and 1877*c*. at the Observatory of the Sheffield Scientific School, 400.

Miscellaneous Scientific Intelligence.—Appearance and Migration of the Locust in Manitoba and the Northwest Territories, summer of 1875, G. M. DAWSON, 401.—The Telephone: Scientific Expedition to the Rocky Mountain Region from Williams College: Scientific Expedition and Summer School of Butler University, Irvington, Indiana: Report of the Chief of Engineers to the Secretary of War, for the year 1876, 402.—Height of "West Hills," Long Island: Strength and Determination of the Dimensions of Structures of Iron and Steel with reference to the latest Investigations, 403.—The Chemist's Manual: Astronomical Myths based on Flammarion's History of the Heavens, 404.

NUMBER LXXVIII.

Page

Art. XLIII.—An account of the Discoveries in Vermont Geology of the Rev. Augustus Wing; by James D. Dana, 405

XLIV.—On Barite crystals from the Last Chance Mine, Morgan County, Missouri; and on Göthite from Adair County, Missouri; by G. C. Broadhead, 419

XLV.—Estimation of Chromium and Aluminium in Steel and Iron; by Andrew A. Blair, 421

XLVI.—On the Chemical Composition of Triphylite, from Grafton, New Hampshire; by Samuel L. Penfield, 425

XLVII.—On a new Mode of Manipulating Hydric Sulphide; by Josiah P. Cooke, Jr., 427

XLVIII.—Report on the Physical Investigations carried on by P. Herbert Carpenter, B.A., in H.M.S. "Valorous," during her Return Voyage from Disco Island in August, 1875; by William B. Carpenter, 437

XLIX.—On the influence of Geological Changes on the Earth's Axis of Rotation; by George H. Darwin, 444

L.—On a Base derived from a Waste-product in the Aniline Manufacture; by C. Loring Jackson, 449

LI.—On an association of Gold with Scheelite in Idaho; by B. Silliman, 451

LII.—Ninth Report of the British Association Committee, appointed for the purpose of investigating the Rate of Increase of Underground Temperature downward in various Localities of Dry Land, and under Water; by Prof. Everett, 452

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Iodine Trichloride, Christomanos, 461.—The Atomic Weight of Selenium, Petterson and Ehman: Trihydroxylantimonic acid and Antimonyl chloride, Daubrawa: The Constitution of Cyanamide, Fileti and Schiff, 462.—Potassium triiodide, Johnson: Ethyl-mercaptan and its Derivatives, Claesson: The Synthesis of Coumarin, Tiemann and Herzfeld: The Decomposition of Glyoxalyl-urea, Medicus, 463.—Two new Alkaloids, Strophantine and Ineine, Hardy and Gallois: Occurrence of Copper normally in the Blood of Wild Animals, Cloëz: Is Glass impervious to Gases? G. Quincke, 464.—Polarization of the Rainbow, M. J. Dechant, 465.—The Radiometer: Fluorescence, M. E. Lommel, 466.—Electricity and the Electric Telegraph, G. B. Prescott, 467.

Geology and Natural History.—Annual Report on the Geographical Surveys west of the 100th Meridian, G. M. Wheeler: Geological and Geographical Survey of the Territories, F. V. Hayden: Contributions from the Laboratory of the University of Missouri, 468.—Organogeny of the Female Flower of Gnetum Gnemon, O. Beccari, 469.—The Paleontological Origin of those trees and shrubs indigenous to the south of France, C. Martins: Alexander Braun, 471.—Notice of Recent Works on Vegetable Paleontology, L. Lesquereux, 472.—Preliminary Note on the Development of Organisms in Organic Infusions, John Tyndall, 477.—On Heat as a Germicide when discontinuously applied, John Tyndall, 480.

Miscellaneous Scientific Intelligence.—National Academy of Sciences, 481.—Excrementitious deposits in the Rocky Mountain region, H. W. Henshaw: Fourth Annual Report of the New Jersey State Board of Agriculture: Primer of Chemistry, including analysis, A. Vacher, 482.

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ART. I.—*Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Sixth paper. With plates I, II and III.

[Read before the National Academy of Sciences, Philadelphia, Oct. 18, 1876.]

Period of unusual heat in June, 1873.

IN June, 1873, an unusually high temperature prevailed throughout a large portion of the United States. At most of the Signal Service stations the thermometer rose above 90° during some part of the month, and at several of the stations there were more than ten days on which the thermometer rose as high as 90°. In the following table, column 1st shows the

Temperature of 90° *in June,* 1873.

Stations.	Latitude.	Elevation. ft.	Cases.	Stations.	Latitude.	Elevation. ft.	Cases.
Fort Sully	44° 39′	1687	17	St. Paul	44° 53′	794	5
Indianola	28 32	25	13	Boston	42 21	77	3
San Antonio	29 25	600	13	Baltimore	39 18	45	2
Mobile	30 42	41	12	Chicago	41 52	657	2
Denver	39 44	5135	11	New York	40 42	165	2
Keokuk	40 23	584	11	Toledo	41 40	649	2
Montgomery	32 22	250	11	Cleveland	41 30	682	1
Washington	38 53	105	10	Fort Garry	49 52	654	1
LaCrosse	43 48	686	8	New Haven	41 17	107	1
Cairo	37 0	352	7	Oswego	42 28	291	1
Louisville	38 18	496	7	Lexington, Ky.	38 8	1083	0
Cincinnati	39 6	614	6	Montreal	45 30	187	0
Leavenworth	39 19	813	6	Morgantown	39 40	991	0
Breckenridge	46 16	966	5	Rochester	43 8	584	0
Cheyenne	41 12	6058	5	Toronto	43 39	342	0
Omaha	41 16	1045	5				

names of the stations at which observations were made with self-registering thermometers; column 2d shows the latitude of the stations; column 3d shows their elevation above the sea, expressed in feet; and column 4th shows the number of days on which the thermometer rose as high as 90°.

The observations at Denver and Cheyenne indicate that on an elevated plateau the extreme heat of summer is at least as great as it is at the level of the sea in the same latitude; while the observations at Lexington and Morgantown show that an elevation of a few hundred feet above the surrounding country has a sensible effect in moderating the extremes of heat. The observations in the vicinity of the Great Lakes as well as those near the Ocean show that large bodies of water have a decided influence in moderating the extremes of temperature.

The stations at which the thermometer rose above 90° in more than three cases are all inland stations; and it is noticeable that at certain northern stations the heat was more intense than at any of the southern stations. At Fort Sully the thermometer rose to 108°; on seven days it rose above 100°; and on twelve days it rose as high as 95°. At Denver the thermometer rose

Observations of the thermometer at $4^h\ 35^m$ P. M., *June* 15–26, 1873.

Stations.	Mean temp. June.	ABOVE OR BELOW THE MEAN TEMPERATURE.											
		June 15.	June 16.	June 17.	June 18.	June 19.	June 20.	June 21.	June 22.	June 23.	June 24.	June 25.	June 26.
Portland, Or.	62°	+ 1	+ 5	— 2	— 1	+ 6	+ 2	— 1	— 3	+ 1	+ 1	+ 6	+ 8
San Francisco	59	+ 3	+ 7	+ 7	+ 7	+ 6	+ 1	+ 2	+ 8	+ 8	— 1	0	+15
San Diego	65	0	+ 4	+ 5	+ 2	+ 2	+ 5	+ 3	+ 2	+ 2	+ 2	+ 3	+ 5
Corinne	69	+19	+20	+14	+18	+18	+20	+13	— 8	— 5	+ 8	+14	+16
Virginia City	56	+28	+24	+12	+ 5	+13	+18	+ 3	—18	— 1	+ 9	+ 4	+ 6
Fort Benton	63	+30	+15	+18	+ 4	+ 9	+13	+ 6	— 4	+ 5	+10	— 8	+ 1
Santa Fe	69	+ 6	+ 3	+ 8	+13	+11	0	+12	+11	+10	+ 4	+12	+15
Denver	69	+12	+19	+21	+26	+13	+23	+21	+23	+15	+23	+18	+24
Cheyenne	65	+14	+22	+21	+21	+10	+25	+20	+11	— 4	+23	+24	+23
Fort Sully	70	+22	+24	+27	0	+12	+24	+25	+20	+ 8	+19	+31	+24
Yankton	71	+12	+14	+14	+10	+ 7	+14	+15	+11	+ 5	+14	+18	+20
Pembina	63	+14	+10	+13	+11	+12	+10	+ 6	+ 4	+ 8	+17	+16	+19
Fort Garry	63	+12	+20	+17	+ 2	+10	+14	+11	+ 4	+10	+10	+19	+19
Indianola	82	+ 6	— 6	— 2	+ 1	+ 5	+ 3	+ 5	+ 3	+ 3	+ 5	+ 3	+ 6
Breckenridge	65	+15	+19	+25	+25	+12	+12	+17	+13	+ 9	+19	+25	+28
Omaha	73	+13	+14	+13	+16	+ 9	+12	+ 7	+ 2	+ 8	+15	+16	+18
Leavenworth	76	+10	+11	+10	+12	+14	+10	+12	+ 7	+ 7	+10	+15	+16
Galveston	82	+ 2	— 7	— 3	— 2	+ 5	+ 7	+ 6	+ 6	+ 7	+ 6	+ 8	+ 8
Shreveport	81	— 2	— 4	+ 2	+ 2	+ 8	+ 9	— 3	+ 6	+ 7	+ 7	+11	+ 9
St. Paul	68	+17	+14	+21	+22	+11	+16	+22	+ 8	+17	+17	+ 5	+22
Duluth	58	+28	+ 2	— 2	+23	+23	+20	— 8	— 8	— 1	— 2	0	— 2
Fort Gibson	79	— 4	+ 6	+ 6	+ 6	+ 5	+ 6	+ 6	+ 7	+ 9	+10	+11	+14
Keokuk	75	+16	+11	+12	+13	+16	+10	+15	+12	+13	+18	+18	+16
LaCrosse	70	+18	+11	+19	+20	+10	+13	+16	+13	+18	+20	+17	+21
Vicksburg	81	— 5	— 3	+ 2	— 1	+ 3	+ 9	+10	+ 9	+10	+11	+ 9	+12

TABLE—continued.

Stations.	Mean temp. June.	ABOVE OR BELOW THE MEAN TEMPERATURE.											
		June 15.	June 16.	June 17.	June 18.	June 19.	June 20.	June 21.	June 22.	June 23.	June 24.	June 25.	June 26.
Davenport	73°	+13	+17	+14	+16	+13	+11	+10	+13	+16	+19	+18	+17
St. Louis	76	+12	+ 7	— 2	+16	+13	+ 2	+ 8	+15	+16	+16	+17	+13
Memphis	79	+ 8	0	— 4	+ 8	+ 6	+12	+12	+14	+13	+15	— 6	+11
New Orleans	80	— 3	+ 5	+ 1	— 1	+ 6	+ 8	+ 9	+ 8	+ 6	+ 3	+ 7	+ 6
Cairo	77	+10	+ 4	+ 6	+ 6	+ 7	+ 9	+10	+12	+12	+14	+ 3	+13
Mobile	80	+ 8	— 4	+ 1	— 4	+10	+ 4	+ 3	+14	0	+12	+13	+ 2
Milwaukee	65	+12	+ 2	— 4	+26	+23	+18	+10	+ 2	+27	+ 4	+ 2	+ 9
Chicago	68	+11	0	0	+19	+22	+ 6	+17	+13	+22	— 2	0	+ 7
Marquette	58	+ 5	+ 1	+ 5	+ 7	+25	+20	— 8	— 4	+11	+ 3	+10	+16
Escanaba	60	+ 8	0	+ 6	+14	+25	+21	+ 4	+ 3	+ 3	+11	+11	+16
Nashville	79	+ 7	— 4	+ 5	+ 7	+ 5	+10	+ 9	+13	— 3	+12	+14	0
Montgomery	80	+ 7	— 1	— 6	+ 6	+12	+13	+10	+12	+14	0	+13	+ 8
Grand Haven	65	+11	+ 7	+ 5	+15	+ 9	+ 3	+12	+13	+15	+12	+22	+14
Indianapolis	75	+11	+ 2	+11	+14	+15	+11	+11	+14	+18	+18	+10	+19
Louisville	77	+10	+10	+ 9	+13	+ 9	+ 7	+10	+ 9	+16	+14	— 4	+10
Cincinnati	76	+10	+15	+ 6	+ 5	+11	+11	+13	+13	+17	+18	+11	+13
Knoxville	74	+11	— 1	+ 9	+ 9	+10	+ 9	+17	+14	+11	+15	+17	+ 7
Toledo	72	+12	+16	+ 4	+15	+18	+11	+12	+14	—11	— 5	+ 2	+11
Alpena	60	0	+14	— 7	+28	+20	+15	— 2	— 4	— 5	+ 2	+ 2	+ 5
Detroit	68	+12	+19	+ 5	+15	+22	+13	+17	— 1	+16	+11	+22	+12
Lake City	79	+ 6	+ 7	+11	+13	+15	+12	+ 8	— 3	+ 5	+10	+10	— 2
Punta Rassa	80	+ 7	+ 7	+ 8	+ 9	+ 9	+ 7	+ 5	+ 4	+ 3	— 7	+ 9	+ 6
Augusta	79	+ 7	+10	+12	+12	+15	+12	+15	+ 9	+10	+12	+ 8	— 4
Key West	83	+ 5	+ 5	+ 5	+ 4	+ 5	+ 5	+ 6	+ 6	+ 6	+ 5	+ 4	+ 3
Jacksonville	80	+ 6	+ 9	+11	+13	+14	+16	— 1	+ 5	+ 6	+ 9	+ 7	+ 1
Cleveland	69	+ 7	+16	+ 5	+13	+20	+10	+10	+11	+13	+ 9	+ 6	+11
Saugeen	60	+ 8	+ 1	— 3	+20	+19	+ 2	— 1	+12	+ 4	+25	+15	+12
Port Stanley	65	+ 9	+12	+ 6	+ 8	+13	+13	+10	— 3	+ 7	— 4	+12	+ 8
Savannah	80	+ 7	+11	+12	+13	+14	+12	+ 4	+ 6	+ 3	+ 8	+10	— 6
Port Dover	65	+ 6	+20	+ 6	+ 5	+ 9	+12	+ 3	— 6	+13	+ 2	+18	+16
Charleston	79	+ 6	+ 9	+11	+11	+ 8	+11	+ 5	+ 4	+ 4	+10	+ 2	— 3
Pittsburgh	72	+11	+ 1	+11	+13	+17	+12	+13	+20	+19	+12	+ 3	+ 9
Toronto	63	+15	+17	+ 2	+ 6	+17	+ 9	+17	— 1	— 2	+ 6	+ 7	+ 4
Lynchburg	74	— 1	+13	— 7	+ 7	+15	+16	+ 9	+13	— 1	— 1	+12	+ 4
Buffalo	65	+ 5	+ 7	+ 8	+ 6	+ 9	+11	+ 7	— 3	+14	+ 5	+16	+11
Wilmington	77	+ 4	+11	+ 4	+16	+17	+15	+13	+11	+12	+16	— 1	+ 3
Rochester	66	+11	+ 4	+ 3	+16	+20	+ 7	+10	— 5	+ 7	+ 1	+12	+16
Washington	75	— 2	+15	+16	+17	+18	+19	+11	+20	+ 4	+ 4	— 1	+10
Baltimore	75	— 5	+13	+13	+12	+18	+19	+13	+14	— 4	+ 2	+ 1	+ 6
Oswego	64	+13	+ 9	+ 5	+15	+18	— 3	+ 4	+ 3	+12	+10	+10	+23
Kingston	63	+ 7	+ 4	— 2	+ 5	+ 8	+13	+11	+ 6	+ 8	+12	+18	+14
Norfolk	76	—12	+13	+10	+12	+16	+20	+10	+16	+14	+14	— 9	+ 2
Philadelphia	72	+ 1	+13	+13	+12	+18	+18	+11	+ 8	— 7	— 8	0	+ 5
Cape May	67	— 4	+ 2	+ 6	+ 2	+ 6	+22	+13	+ 8	+ 2	+ 1	+ 1	+ 2
New York	69	+ 1	+13	+13	+ 3	+19	+20	+12	0	— 5	— 8	0	+ 5
Montreal	66	+ 6	+ 7	+ 1	+ 1	+ 4	+ 4	— 5	+ 1	+ 4	+ 7	+ 6	+ 7
Burlington	66	+13	+13	+ 1	+ 6	+14	+ 9	— 6	+ 5	+11	+11	+17	+18
New London	65	+ 3	+12	+15	+ 5	+23	+22	+14	+ 5	0	— 2	+ 2	+10
Mt. Washington	43	+ 4	+ 8	— 6	+ 1	+10	+ 6	— 9	— 7	+ 3	+ 5	+12	+14
Quebec	64	+10	+10	0	—17	— 7	— 1	— 5	+ 5	+11	+13	+18	+15
Boston	67	+15	+22	+15	+14	+24	+18	+ 8	+ 2	+ 7	+ 6	+ 9	+21
Portland, Me.	62	+ 3	+15	+14	+ 1	+ 3	+21	+ 5	+ 3	+ 4	+10	+12	+ 8
Eastport	55	+ 3	0	+12	+10	— 6	— 1	0	+ 7	+16	+ 5	+13	+ 9

to 99°, and on five days it rose as high as 95°. At Indianola the highest temperature was 97°·5, and only twice did the thermometer rise as high as 95°. At San Antonio the highest temperature was 96°, and only once did the thermometer rise as high as 95°. At Mobile the highest temperature was 95°, and these are the highest temperatures reported at any of the southern stations. We thus see that at Fort Sully and Denver the thermometer rose higher than it did at any of the southern stations.

If we consider simply the height of the thermometer above the mean temperature of the month, we find that by far the most remarkable cases occurred at stations north of latitude 40°. The preceding table exhibits the observed changes of temperature from June 15 to June 26. Column second shows the mean temperature of June at the stations named in column first, and the succeeding columns show the difference between the mean temperature of the month and the temperature observed each day at $4^h\ 35^m$ P. M. At this hour the temperature at most of the stations is about 8° above the mean temperature of the day, so that nearly all the numbers given in this table should be diminished by about 8° in order to show the elevation above the mean temperature at the hour of observation; and at a few of the stations a still larger correction is required.

In order to exhibit more clearly the conclusions to be derived from the numbers in the preceding table I have prepared the following summary, in which column second shows for each day at what station the temperature rose *most* above the mean for the month; column third shows how much the thermometer rose above the mean; column fourth shows the state of the barometer at the given station, and column fifth shows the lowest barometer observed on the given day at any of the stations.

Temperatures most above the mean.

Date.	Stations.	Temperature.	Barom.	Lowest barom.
June 12	Fort Benton	+19°	29·97	29·64
13	Fort Sully	+21	29·68	29·68
14	Breckenridge	+19	29·59	29·46
15	Fort Benton	+30	29·80	29·63
16	Virginia City	+24	29·67	29·64
"	Fort Sully	+24	29·69	29·64
17	Fort Sully	+27	29·52	29·38
18	Alpena	+28	29·54	29·26
19	Escanaba	+25	29·52	29·49
"	Marquette	+25	29·53	29·49
20	Cheyenne	+25	29·90	29·41
21	Fort Sully	+25	29·46	29·46
22	Denver	+23	29·61	29·30
23	Milwaukee	+27	29·77	29·57
24	Saugeen	+25	30·06	29·62
"	Denver	+23	29·87	29·62
25	Fort Sully	+31	29·52	29·52
26	Breckenridge	+28	29·68	29·68

We see from this table that the stations at which the thermometer rose most above the mean were all north of lat. 39°, and they are all situated between the Rocky Mountains and the meridian of 81° west of Greenwich. We also see that a high temperature was generally accompanied by a barometer below the mean; the average pressure shown in column fourth being 29·70. Column fifth shows that on each day there was a considerable barometric depression in some part of the United States and the center of this depression was always north of lat. 40°, and the region of greatest heat was always within the influence of the area of depressed barometer. In four instances the station which showed the greatest rise of temperature showed also the greatest depression of the barometer.

In order to exhibit more clearly the form and position of these heated areas I have prepared Chart I, which shows the thermic isabnormals for June 18th, at 4^h 35^m, P. M., the curves being drawn at intervals of 5°.

From this chart we perceive that near the Gulf of Mexico, and also near the northeast and northwest angles of the United States, the temperature was below the mean for the month of June, but in every other portion of the United States the temperature was above the mean for the month. In order to determine how much the mean temperature at the hour of observation exceeds the mean temperature of the month, I have compared the observations of maxima and minima temperatures at all the Signal Service stations as far as they have been published in the annual Reports. I have taken the mean of the maxima of temperature for the month of June at each station, and also the mean of the minima. The difference between these two months I call the mean diurnal oscillation of the thermometer. I have made this comparison for each of the years 1873, 4, and 5. The following table shows all the Signal Service stations at which the mean diurnal oscillation exceeds 22°, and also all those stations at which the oscillation is less than 15°. Column second shows the mean diurnal oscillation for the month of June at the stations named in column first; column third shows the number of years of observation; column fourth shows the height of the station above the sea; column fifth shows the annual rain-fall at each station; and column sixth shows the rain-fall in 1873, from June 12th–26th inclusive.

Since we have a series of hourly observations of the thermometer at Philadelphia and Toronto we can compute the correction to be applied on account of the hour of observation at each of the preceding stations, if we assume that the correction at different stations is proportioned to the entire daily oscillation. We thus find that at the hour of 4·35 P. M., Washington

Diurnal oscillation of temperature in June.

Stations.	Oscillation	Years.	Elevation. ft.	Annual rain-fall.	Rain-fall 15 days.
Colorado Springs	33°·7	2	5935	13·69	
Denver	32·2	3	5135	13·99	0·02
Cheyenne	31·6	3	6058	8·60	0·22
Santa Fe	30·7	2	6862	13·36	0·02
Dodge City	28·2	1	2482	6·49	
Fort Sully	26·7	3	1687	12·16	0·34
Virginia City	25·7	3	5510	16·43	0·28
Salt Lake City	25·4	2	4350	17·93	0·05
Fort Garry	25·3	3	654	14·48	1·09
Ottawa	24·7	2	250	29·33	
North Platte	24·6	1	2846	13·64	
Corsicana	24·3	1	447	25·42	
Pittsburgh	23·5	1	955	37·53	0·86
Stayner	23·5	1	714	28·26	
Bismark	23·3	1	1677	21·09	
Wytheville	23·3	2	2294	44·15	
Shreveport	22·9	2	228	49·60	3·89
Pembina	22·8	2	790	12·99	1·37
Island of St. Paul	7·0	2		55·85	
Cape Hatteras	8·8	1	7	64·38	
Cape Rozier	9·7	1	39	33·81	
Key West	10·6	3	17	37·60	
Cape May	11·0	1	14	46·87	
Mt. Washington,	11·4	3	6285	66·47	
New Orleans	11·9	2	56	61·46	
San Diego	12·0	2	62	9·16	
Wood's Hole	12·1	2	25	39·36	
Galveston	12·9	2	40	46·66	
Charleston	13·0	2	61	44·18	
San Francisco	13·4	2	60	20·20	
Indianola	13·6	3	25	41·98	
Atlantic City	13·8	2	23	36·16	
Punta Rassa	13·8	2	17	53·42	
Buffalo	14·8	2	662	34·36	
Kitty Hawk	14·9	1	22	45·02	

time, the temperature exceeds the mean of the month by the following quantities:

Correction for hour of observation.

Stations.	Correc.	Stations.	Correc.	Stations.	Correc.
Denver	13°	Virginia City	10°	Saugeen	8°
Cheyenne	13	Breckenridge	9	Escanaba	7
Fort Sully	10	Alpena	8	Marquette	7
Fort Benton	10	Milwaukee	8		

Applying these corrections to the numbers given on page 4 we find that on June 15th the thermometer at Fort Benton rose 20° above the mean temperature of that station at the hour of observation; on the 18th at Alpena it also rose 20°, and on the 25th at Fort Sully it rose 21° above the mean temperature at the hour of observation. We are then required to explain how the thermometer should rise 20° above the mean temperature of the hour and place.

The accompanying Chart, Plate II, shows the isobaric curves for the same date as the temperature curves of Plate I. We perceive that throughout the entire United States, with the exception of the Pacific coast and the vicinity of the Gulf of Mexico, the pressure of the atmosphere was less than 30 inches; and in Minnesota the pressure was 29·30. This barometric minimum would lead us to look for southerly winds throughout the valley of the Mississippi. The actual direction of the winds observed is shown by arrows on Chart I. The following table shows the number of stations at which the wind blew from each of the eight principal points of the compass.

Direction of the winds, June 18th, 4^h 45^m P. M.

Wind.	No. of Stations.	Wind.	No. of Stations.
North	3	South	20
Northeast	2	Southwest	27
East	4	West	7
Southeast	7	Northwest	7

We see that at 54 stations the wind blew from some southern quarter, and at only 12 stations did it blow from a northern quarter. The following are the stations in question:

North wind at Cleveland, Mobile and Santa Fe.

Northeast wind at Duluth and Yankton.

Northwest wind at Eastport, Fort Garry, Fort Sully, Mt. Washington, Norfolk, Oswego and Pembina.

At three of these stations, viz: Cleveland, Duluth and Oswego, the northerly wind was probably the result of the cooler air of the Lakes moving toward the warmer land. Three of the stations, viz: Fort Sully, Fort Garry and Pembina, were situated on the north side of the area which was most heated; and two other stations, viz: Eastport and Mt. Washington were on the extreme eastern border of the heated area. At Mobile the velocity of the wind was only *one mile* per hour; at Norfolk and Yankton it was four miles; and at Santa Fe five miles per hour.

We thus see that throughout the entire heated area (with a few trifling exceptions which are easily explained) the movement of the atmosphere was from the south. This general movement from the south had prevailed for more than 24 hours with an average velocity of about ten miles per hour, which should cause a rise in the thermometer of from 6 to 10 degrees in the vicinity of the western Lakes; that is, this cause seems to be sufficient to account for nearly (if not fully) half of the rise actually observed.

A considerable part of the remaining rise may probably be ascribed to the accumulated effect of the sun's radiation for many successive days without the interference of northerly winds. As early as the 10th of June there was a large rise of the thermometer at Fort Benton and Virginia City, and this was maintained pretty steadily until the 17th. This heated air drifted slowly to the eastward and on the 18th reached the neighborhood of the Great Lakes.

The great diurnal oscillation of temperature observed at Denver and its vicinity, probably depends somewhat upon the configuration of the surrounding country, but the most important circumstance is the extreme dryness of the climate of this region. In a country where the annual rain-fall is small, and the surface of the earth becomes very dry, the earth readily absorbs the rays of sun, and there is little evaporation to counteract their heating effect. The thermometer therefore during the day time rises higher than it would if the earth were moist and covered with green grass. At night, on the contrary, the heat is rapidly dissipated, and there is no vapor to be condensed, which by the latent heat liberated would counteract the effects of radiation. Thus during the night the thermometer sinks lower than it would in a moist atmosphere.

The same phenomenon is noticed in other countries which have a dry climate. At Madrid in Spain the mean diurnal oscillation of the thermometer is much greater than in most parts of Europe. The following table shows the difference between the mean of the daily maxima and the daily minima at Madrid for the months of June and July during a period of eight years. The fourth column shows the highest temperature observed during each year, and the fifth column shows the rain-fall of each year expressed in English inches.

Range of thermometer at Madrid, Spain. Height, 1939 *feet.*

Years.	June.	July.	Highest temp.	Annual rain-fall.
1866	25°·2 Fahr.	29°·3 F.	101°·1 F.	19·82
1867	30·8	31·5	100·8	15·04
1868	31·1	30·2	102·7	11·83
1869	30·6	32·2	105·1	11·04
1870	32·0	32·8	104·7	12·81
1871	27·0	32·6	108·3	16·22
1872	32·8	33·1	106·3	15·30
1873	27·9	32·8	104·6	15·07
Mean	29·7	31·8	104·2	14·64

The last column in the table on page 6 shows that in June, 1873, an unusual drought prevailed throughout Colorado, Wyoming and Montana. In consequence of this extreme dryness, the heating effect of the sun's rays was greatly increased, and this cause combined with the prevalent southerly winds will probably explain the extreme heat observed in that region. The heat experienced in the neighborhood of the Great Lakes may be ascribed partly to the same causes operating in that locality, and partly to a mass of heated air drifted eastward from the dryer regions of the West.

The remarkable heat recorded at Fort Sully and mentioned on page 2, seems to indicate some peculiarity of that locality. In order to discover the nature of this peculiarity I have collected all the cases in which a temperature of 100° and upward is mentioned in the annual Reports of the Signal Service for 1873, 4, and 5. The following table shows the number of such cases for each year. For the year 1875 the observations include only the first six months of the year. The mark (*) shows that no observations of self-registering thermometers were received from the stations indicated.

Number of cases of a temperature of 100° *Fahr.*

	1873.	1874.	1875.		1873.	1874.	1875.
Fort Gibson	*	21	0	Louisville	0	3	0
Shreveport	*	3	18	Denver	0	2	0
Fort Sully	20	13	2	Dodge City	*	0	2
Leavenworth	0	12	0	Keokuk	1	2	0
Nashville	*	7	0	LaCrosse	*	2	0
Omaha	0	6	0	Augusta, Ga.	*	1	0
Cairo	0	4	0	Cincinnati	0	1	0
Corsicana	*	0	4	Indianola	0	1	0
Memphis	*	4	0	Jacksonville	*	1	0
Montgomery	0	4	0	Mobile	0	1	0
St. Louis	*	4	0	Washington	1	1	0
Dubuque	*	3	0	Yankton	*	1	0

These observations show that the thermometer seldom rises to 100° in the vicinity of the Atlantic Ocean, the Gulf of Mexico, or the Great Lakes. Cases of extreme heat are of most frequent occurrence between the Mississippi River and the Rocky Mountains. They are the effect of the dryness of the soil and of the atmosphere in that region; and they serve to intensify the dryness from which they result. If we compare the high temperatures observed at Fort Sully with the observations at neighboring stations, we shall perceive that they are altogether exceptional. The first column of the following table shows a series of stations on the Missouri River; column second shows the latitude of the stations; column third shows their elevation (in feet) above the ocean; and column fifth shows the number of cases in which the thermometer, in 1873, 4, and 5, was observed to rise as high as 100°.

Temperature of 100° *Fahr.*

	Latitude.	Elevation.	Cases.
Leavenworth ..	39° 19′	813	12
Omaha........	41 16	1045	6
Yankton	42 45	1296	1
Fort Sully.....	44 39	1687	35
Bismark	46 48	1677	0

The first three stations, together with the fifth, show a steady decline in the intensity of the heat as we advance northward; but Fort Sully shows temperatures much greater than occur at stations several hundred miles southward. At this station the meteorological instruments are located within the walls of the fort, and the thermometers are probably influenced by heat reflected from dry sand, and stone walls. This seems to be the most probable explanation of the excessive heat reported at Fort Sully.

Rain-areas—their form, movements, distribution, etc.

In order to investigate the form of rain-areas; the laws which govern their movements, and their relations to the isobaric curves I selected all those cases during a period of fifteen months (Sept. 1872 to Nov. 1873) in which at least two inches of rain fell at one station in eight hours. These cases were then divided into two classes, one containing the stations south of latitude 36°, and the other containing the stations north of latitude 36°. The following table exhibits all the cases which occurred at the southern stations. Column first contains the number of reference, column second shows the day and hour of observation (the numeral one denotes the 7.35 A. M. observation; two denotes 4.35 P. M., and three denotes 11 P. M.); column third shows the station at which the greatest rain-fall was observed; column fourth shows the precise amount of the rain: column fifth shows the height of the barometer at the same station; column sixth shows the direction and force of the wind at the last *preceding* observation; column seventh shows the direction and force of the wind at the date given in column second; column eighth shows whether the direction of the winds at the neighboring stations indicated a cycloidal or inward motion; column ninth shows whether there was any local depression of the barometer; and column tenth shows whether there was a high or a low barometer on the north side of the given station.

For a large number of these cases I have drawn upon maps of the United States, the curves of equal rain-fall for each fourth of an inch. These curves show that when there is only one principal center of precipitation, the form of the rain-area is nearly circular, and its diameter varies from 350 to 750 miles.

Rain-fall of two inches at Stations south of lat. 36°.

No.	Date.	Station.	Rain. In.	Bar.	Wind at prev. ob.	Wind at date.	Cycloidal motion.	Local dep'n.	On N. side.
	1872.								
1	Sept. 10–2	Jacksonville.	2·42	30·09	S.E. 3	N. 2	probable	none	low
2	11–2	Montgomery.	2·00	29·93	E. 4	S.E. 2	decided	slight	low
3	25–1	Shreveport.	2·05	30·11	W. 5	N.E. 14	decided	none	low
4	26–1	Wilmington.	2·09	30·05	Calm	S. 4	decided	none	high
5	30–1	Charleston.	2·07	30·01	S.W. 6	N.E. 6	decided	none	low
6	Oct. 9–2	New Orleans.	2·19	29·96	E. 8	E. 8	decided	slight	high
7	22–2	Punta Rassa.	2·06	29·92	E. 23	S.E. 15	decided	slight	high
8	22–3	Jacksonville.	2·43	29·99	N.E. 12	E. 13	decided	slight	high
9	23–1	Jacksonville.	2·05	29·83	E. 13	W. 1	very dec'd	decided	high
10	29–2	Shreveport.	2·24	29·95	Calm	S.W. 10	not dec'd	slight	low
11	Nov. 6–1	Galveston.	3·75	29·76	E. 2	S.E. 28	decided	decided	low
12	6–3	Montgomery.	2·73	29·95	E. 3	S.E. 22	decided	slight	high
13	8–1	New Orleans.	3·15	29·85	N.E. 16	N. 18	decided	slight	high
14	8–2	Mobile.	2·04	29·84	N.E. 8	E. 12	decided	decided	high
15	Dec. 10–1	Indianola.	2·14	29·86	N.E. 35	N. 40	decided	slight	high
16	18–2	New Orleans.	2·20	30·08	S.W. 6	N.E. 8	decided	none	high
	1873.								
17	Jan. 5–1	Lake City.	2·00	29·89	S.E. 4	S.E. 7	decided	slight	low
18	16–1	New Orleans.	2·01	29·92	S. 8	N.W. 12	decided	slight	low
19	Mar. 29–1	Lake City.	2·00	29·97	N.E. 8	N.W. 12	decided	slight	low
20	April 29–2	Savannah.	2·15	29·99	S. 10	Calm	slight	slight	low
21	May 1–2	Montgomery.	3·05	29·87	S.E. 4	S.E. 4	slight	slight	low
22	5–3	New Orleans.	2·40	29·81	E. 12	E. 16	decided	decided	low
23	6–1	Mobile.	2·34	29·85	N.E. 6	N.E. 16	decided	decided	low
24	18–2	Galveston.	2·00	29·77	S.E. 16	N.E. 22	decided	decided	low
25	19–2	Mobile.	2·47	29·99	N.W. 1	N. 8	not dec'd	none	low
26	20–2	New Orleans.	2·08	29·92	N. 3	S.E. 12	slight	slight	low
27	June 1–1	Key West.	2·05	30·00	N.E. 2	S.W. 6	decided	slight	high
28	8–2	Mobile.	2·10	30·01	S.W. 2	W. 1	decided	small	low
29	10–3	Memphis.	2·68	29·98	S.E. 8	N.E. 4	decided	small	
30	July 21–2	Mobile	2·30	30·07	N. 4	S. 8	decided	none	low
31	22–2	Mobile.	3·14	30·18	N.E. 16	E. 16	slight	none	low
32	Aug. 2–2	Punta Rassa.	3·32	30·06	N.E. 4	N. 2	decided	none	low
33	6–1	Charleston.	2·05	30·23	N.E. 4	N.E. 8	none	none	high
34	8–3	Vicksburg.	2·00	30·08	Calm	Calm	not dec'd	none	high
35	9–2	New Orleans.	2·03	30·02	E. 12	E. 10	doubtful	not dec'd	low
36	17–3	Punta Rassa.	2·69	30·11	S.W. 13	E. 5	not dec'd	none	high
37	20–2	Jacksonville.	3·72	30·06	S.E. 4	E. 20	decided	none	high
38	21–1	Galveston.	3·67	29·95	E. 5	Calm	decided	slight	low
39	21–2	Mobile.	2·04	29·96	N.E. 4	E. 8	decided	slight	low
40	30–2	Indianola.	2·16	30·20	S.E. 20	N. 6	not dec'd	none	low
41	Sept. 13–2	Galveston.	2·95	29·97	N.E. 9	N.E. 14	not dec'd	not dec'd	high
42	18–1	Mobile.	2·35	29·90	N.E. 7	E. 12	decided	small	low
43	18–2	Mobile.	2·73	29·90	E. 12	E. 12	decided	small	high
44	20–1	Wilmington.	2·38	29·82	N.E. 8	N.W. 14	decided	small	low
45	26–2	Indianola.	2·96	29·85	S.E. 20	S. 14	doubtful	not dec'd	low
46	Oct. 3–1	Jacksonville.	2·74	30·04	N. 12	N.W. 4	doubtful	not dec'd	high
47	Nov. 1–1	Havana.	2·80	30·11	N.E. 11	N.E. 10	doubtful	small	high
48	2–3	Galveston.	3·50	30·05	S. 16	S. 12	decided	small	high
49	5–2	Montgomery.	2·97	30·06	Calm	S.E. 1	decided	small	high
50	17–2	Havana.	2·88	29·73	S.W. 5	N.W. 6	probable	doubtful	low
51	22–3	Shreveport.	2·16	29·80	N. 5.	S.E. 5	decided	decided	low
52	29–1	Havana.	2·10	30·18	N.W. 6	N.E. 4	probable	doubtful	high

These excessive rain-falls are not of long continuance, but their exact duration cannot be determined from the observations. In two cases (viz., Nos. 8 and 42) over two inches of rain fell in two successive periods of eight hours at the same station; and in a few other cases these great rain-falls were followed during the next eight hours by a fall of one inch or more, either at the same station, or at a station a little to the eastward. The following table shows all the cases in which any of these heavy rain-falls were followed by one inch of rain at a neighboring station during a succeeding period of eight hours.

Cases of heavy rain continuing more than eight hours.

Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.
1872.											
Sept. 11–2	2·00	Montgomery.	11–3	1·10	Lake City.						
Oct. 22–2	2·06	Punta Rassa.	22–3	2·43	Jacksonville.	23–1	2·05	Jacksonville.	23–2	1·58	Charleston.
Nov. 6–1	3·75	Galveston.	6–2	1·88	Galveston.	6–3	2·73	Montgomery.			
Nov. 8–1	3·15	New Orleans.	8–2	2·04	Mobile.						
Dec. 10–1	2·14	Indianola.	10–2	1·03	Galveston.						
1873.											
Jan. 5–1	2·00	Lake City.	5–2	1·19	Norfolk.						
May 1–2	3·05	Montgomery.	1–3	1·80	New Orleans.						
May 5–3	2·40	New Orleans.	6–1	2·34	Mobile.	6–2	1·11	Montgomery.	6–3	1·64	Jacksonville.
May 20–2	2·08	New Orleans.	20–3	1·21	New Orleans.						
Aug. 21–1	3·67	Galveston.	21–2	2·04	Mobile.						
Sept. 18–1	2·35	Mobile.	18–2	2·73	Mobile.						
Oct. 3–1	2·74	Jacksonville.	3–2	1·25	Jacksonville.						

In three cases we find three successive periods of heavy rain-fall, and in two cases we find four such periods, indicating a duration of heavy rain for thirty-two hours. We conclude therefore that great rain-falls do not generally continue over eight hours, and very rarely do they continue for twenty-four hours, either as experienced at one station, or in succession at different places.

These heavy rain-falls appear to result from the unstable condition of the different strata of the atmosphere. When the atmosphere near the earth's surface becomes unusually heated it tends to ascend; and if this atmosphere contains a large amount of aqueous vapor, its specific gravity is thereby diminished and it has a much stronger tendency to ascend. It thus frequently happens that the atmosphere is in a state of unstable equilibrium, and a slight cause is sufficient to determine a strong upward movement of the surface air, resulting in a precipitation of vapor. When air in this unstable condition has a movement along the earth's surface, a slight inequality of the surface may be sufficient to determine an upward movement at that point. We should therefore conclude that when a current of warm and moist air flows in from the ocean and impinges upon the land, a strong upward movement accompanied by heavy precipitation must frequently result. This conclusion is confirmed by a comparison of the preceding observations. Among the stations of the Signal Service south of latitude 36°, there are twelve stations situated on the Atlantic coast or the Gulf of Mexico. At these stations during a period of fifteen months the average number of great rain-falls (two inches in eight hours) has been 3·6. Among the stations of the signal service south of latitude 36°, there are also five inland stations, whose average distance from the coast is 200 miles, and during the same period the average number of great rain-falls at these stations has been 1·8; that is, near the coast great rain-falls occur *twice* as frequently as they do at stations in the interior at a distance of 200 miles from the coast.

Whenever a strong upward movement of the air commences, there must be a general tendency of the surrounding air toward this point, and the air must circulate from right to left as it does in great storms. Hence every great rain-storm should be accompanied by an inward and cycloidal motion of the air. In about two-thirds of the preceding cases there is decided evidence of the existence of such a cycloidal movement, and in most of the remaining cases there are some indications of such a movement. If observations could be obtained from a sufficient number of stations, it is believed that some degree of cycloidal motion would be indicated in every case of heavy rain-fall.

The depression of the barometer attending these rain-falls was generally small, nevertheless in several cases it was quite appreciable. At the time of the observations shown in the table on page 11, the average height of the barometer was less than thirty inches, while the mean height throughout the year at the same stations was nearly 30·10 inches. That a cycloidal movement of the air should produce so little depression of the barometer is due to three circumstances; first, the small velocity of the wind (averaging less than nine miles per hour); second, the small area of the cycloidal movement (generally about 500 miles in diameter), and third, the proximity of the stations to the equator. According to Ferrel's formula any great barometric depression requires a strong wind; the cycloidal movement must extend over a large area; and the depression of the barometer is proportioned to the sine of the latitude of the place. In about half of the preceding cases there was an area of low barometer prevailing in the northern portion of the United States, and about as frequently, there was an area of high barometer on the northern side of the station. These different conditions appear to be about equally favorable to heavy rain-falls.

The distribution of these fifty-two cases by seasons was as follows:

Spring, 8; Summer, 14; Autumn, 14 and 12; Winter, 4.

We thus see that great rain-falls are most frequent when the heating effect of the sun's rays is greatest and the atmosphere contains the greatest amount of vapor.

The distribution of these cases according to the hours of the day was as follows:

At the	7.35 A. M. obs.	19 cases.
	4.35 P. M.	25 "
	11.00 P. M.	8 "

The intervals between the observations, which for convenience I have called eight hours, are in fact unequal. Making, however, due allowance for inequality of intervals, it seems clear that in the United States, south of latitude 36°, heavy rain-falls are less frequent from 4.35 P. M. to 11 P. M., than during the remainder of the day. If we knew the precise time of beginning and end of each rain-fall we might determine the precise hour of maximum and of minimum frequency of heavy rain-falls.

On Plate III are shown the curves of equal rain-fall for June 10, 1873, being No. 29 of the table on page 11. The outer curve shows the extreme limits of the rain-area; the next curve shows the limits of a rain-fall of one inch; and the inner curve shows the limits of a rain-fall of two inches. The arrows show the direction of the wind as reported at 4.35 P. M., which is presumed to have been about the time of the commencement of the rain-fall. There was a center of low pressure (29·71) near Lake Ontario, and a center of high pressure (30·16) near Charleston, S. C. As the result of this unequal pressure, southerly winds generally prevailed throughout the Southern States. A northwest current had however set in from the neighborhood of Minnesota, and this wind had reached St. Louis and Fort Gibson. The temperature at St. Louis was 71°, while at Memphis it was 87°. This cooler wind from the northwest probably flowed under the southeast wind from Memphis, causing it suddenly to ascend, and thus produced a rapid precipitation of vapor.

Rain-fall of two inches at stations north of lat. 36°.

The following table contains all the cases in which at least two inches of rain fell in eight hours at any of the northern stations from Sept., 1872, to Nov., 1873. Column 1st contains the number of reference; column 2d shows the day and hour of observation; column 3d shows the station at which the

Rain-fall of two inches at stations north of lat. 36°.

No.	Date.	Station.	Rain. In.	Bar.	Wind		Rain center from Low.		Low bar.
					at prev. ob.	at date.	Direction.	Distance.	
	1872.								
1	Sept. 23–2	Grand Haven.	2·89	29·77	S.E. 6	S.E. 7	East	660	29·35
2	26–2	Mt. Washington.	2·27	30·14	S.W. 43	S.W. 32	S. 80 E.	733	29·59
3	28–3	Chicago.	2·02	29·35	N.E. 22	N.E. 11	*	00	29·35
4	Oct. 25–1	Norfolk.	3·41	29·95	E. 13	S.E. 8	*	00	29·95
5	26–1	Philadelphia.	2·09	29·78	E. 20	S.W. 12	S. 54 E.	137	29·74
6	Nov. 7–1	New York.	2·50	29·68	S.E. 4	N.W. 10	S. 65 E.	777	29·33
7	Dec. 26–1	Norfolk.	2·08	29·46	N.E. 21	N. 20	*	00	29·46
	1873.								
8	Jan. 5–2	Philadelphia.	2·18	29·61	N.E. 20	N.E. 8	S. 58 E.	218	29·45
9	May 1–1	Nashville.	2·20	29·73	S.E. 4	E. 25	S. 64 E.	420	29·58
10	9–2	New London.	2·35	30·06	N.E. 4	N.E. 26	N. 83 E.	696	29·62
11	22–1	Lynchburg.	2·10	30·00	N.E. 4	Calm	S. 80 E.	886	29·45
12	June 9–3	St. Louis.	2·93	29·87	S. 8	S. 5	S. 21 W.	420	29·70
13	22–3	St. Paul.	2·28	29·55	S.E. 13	S.E. 18	N. 70 E.	185	29·43
14	23–1	St. Paul.	2·30	29·57	S.E. 18	S.W. 2	S. 70 E.	88	29·52
15	July 2–1	Indianapolis.	2·04	29·94	S.E. 12	S.W. 3	S. 5 E.	218	29·77
16	16–1	Marquette.	2·10	29·94	Calm	S. 8	N. 88 E.	549	29·47
17	16–2	Fort Garry.	2·45	29·49	E. 10	S. 5	*	00	29·49
18	17–3	Buffalo.	2·00	29·64	S.W. 14	S.W 7	*	00	29·64
19	26–1	Buffalo.	2·20	29·83	S.E. 4	Calm	N. 56 E.	160	29·81
20	27–2	Washington.	2·12	30·11	S. 10	W. 8	S. 63 E.	1175	29·72
21	27–3	Philadelphia.	2·03	30·16	N.W. 8	S. 8	S. 64 E.	1140	29·85
22	Aug. 13–1	Philadelphia.	2·31	30·04	E. 16	N.E. 12	N. 70 E.	360	29·92
23	13–2	Philadelphia.	2·17	29·97	N.E. 12	N.E. 22	N. 40 E.	350	29·85
24	13–3	Baltimore.	3·26	29·86	N.E. 12	N.E. 12	North	40	29·86
25	14–1	Breckenridge.	2·05	29·86	S. 16	S.E. 16	N. 53 E.	187	29·71
26	25–2	Erie.	2·00	29·82	S.E. 1	W. 4	North	312	29·70
27	Sept. 10–1	Norfolk.	2·05	30·16	Calm	E. 4	N. 22 E.	668	29·97
28	19–3	Mt. Washington.	2·20	29·86	S.W. 24	W. 12	North	202	29·59
29	Oct. 7–1	Portland, Me.	2·02	29·40	N. 12	N. 20	*	00	29·40
30	19–3	New London.	2·25	29·80	S.E. 2	S.E. 24	N. 34 E.	329	29·52
31	Nov. 24–2	New London.	2·80	29·30	S.E. 14	N. 1	S. 61 W.	90	29·27

greatest rain-fall was observed; column 4th shows the precise amount of the rain-fall; column 5th shows the height of the barometer at the same station; column 6th shows the direction and force of the wind at the last *preceding* observation; column 7th shows the direction and force of the wind at the date given in column 2d; column 8th shows the direction of the rain center from the nearest center of low pressure; column 9th shows the distance of the rain center from the center of low pressure, expressed in miles; and column 10th shows the height of the barometer at the center of low pressure.

In all of these cases there was an area of low pressure within the limits of the United States, and generally the place of greatest rain-fall was within the cycloidal movement attending this low pressure. The distance of the rain center from the center of low pressure was however very variable.

In 16 cases the distance was less than 250 miles.
6 " " between 250 and 500 miles.
5 " " between 500 and 750 miles.
4 " " over 750 miles.

In the two cases of July 27th, the low pressure was so inconsiderable and remote as to exert very little influence upon the winds at Philadelphia and Washington.

We thus see that north of lat. 36° great rain-falls generally occur within 250 miles of a center of low pressure, and almost invariably on the east side of the low center. In two of the preceding cases (Nos. 12 and 31) the rain center is stated to be west of the low center. But it should be remembered that the rain-fall occurred during the eight hours preceding the date of the barometric observation. The middle of the rain-fall may be regarded as corresponding to a date four hours preceding the barometric observation, and during these four hours, the low center generally advances eastward 100 miles. We may therefore conclude that in No. 31 the principal rain-fall occurred when the rain center was east of the low center. In No. 12 the principal rain-fall occurred on the southwest side of the low center, but the barometric gradient was only one-tenth of an inch to 350 miles. The rain center occurs as frequently in the N.E. quarter from the low center as it does in the S.E. quarter.

The four cases in which the rain center was more than 750 miles distant from the nearest center of low pressure were Nos. 6, 11, 20 and 21. In No. 6 a distinct local cyclone formed near New York, accompanied by a slight local depression of the barometer, which had the effect of urging the low center eastward with extraordinary velocity. From 7.35 A.M. to 4.35 P.M., that is, in nine hours, the low center advanced eastward 900 miles, although the greatest velocity of the wind, recorded anywhere near the path of the storm, was thirty-eight miles per hour (on Mt. Washington), indicating that the progress of the low center was not due wholly to the transfer of air from west to east, but rather to a *diminution* of the pressure on the east side of the low, and an *increase* of the pressure on its western side.

In No. 11 Lynchburg was somewhat nearer to a center of high pressure than of low pressure. There are indications that a small local cyclone formed about Lynchburg, but the stations of observation are too few to show this conclusively.

In Nos. 20 and 21 the rain center was much nearer to a center of high pressure than of low pressure. At 4.35 P. M. a distinct local cyclone was shown about Baltimore, Washington, and Cape May, but the cyclonic area was of small diameter and its effect upon the barometer was scarcely appreciable.

We thus see that great rain-falls may occur under the influence of an area of high pressure as well as of low pressure, and when they occur at a great distance from a low center, they are generally accompanied by a distinct local cyclonic movement of the atmosphere.

Of the thirty-one cases included in the preceding table, fifteen occurred on the Atlantic coast, and the number of stations of observation upon the coast was eleven; which shows an average of 1·37 to each station. For the remainder of the United States there were sixteen cases, and the number of stations was fifty-nine, showing an average of 0·27 to each station. Thus we see that north of lat. 36° near the Atlantic coast, great rain-falls are *five times* as frequent as in other parts of the United States in the same latitude. The frequency of heavy rain-falls in the neighborhood of the great lakes is not sensibly greater than at inland stations quite distant from the lakes.

The distribution of these 31 cases by seasons was as follows:

Spring 3; summer 15; autumn 6 and 5; winter 2.

Showing a predominance of great rain-falls in summer even more decided than at the southern stations.

The distribution of these cases according to the hours of the day was as follows: 7·35 A. M., 14 cases; 4·35 P. M., 9 cases; 11 P. M., 8 cases.

If we correct these numbers for the inequality of the time intervals, there is still an excess of cases for the morning hour of observation.

The following table shows all the cases in which any of these heavy rain-falls were followed by at least one inch of rain during a succeeding period of eight hours.

At the southern stations, out of fifty-two cases of heavy rain there were twelve cases in which heavy rain continued through two periods of eight hours; at the northern stations out of thirty-one cases there were thirteen which continued through two periods, indicating that heavy rains are of longer duration at the northern stations than they are at the southern. In two instances the center of the rain area apparently moved westward. Thus on the morning of July 16th, the center of the rain area was at Marquette, which was more than 500 miles eastward of the center of low pressure; but in the afternoon the center of the rain area coincided with the center of low pressure; that is, the center of the rain area moved toward the northwest. So also on the morning of May 1st, the center of the rain area was more than 400 miles eastward of the center of low pressure; in the afternoon the center of the rain area extended southward; and during the evening it extended toward the southwest.

Cases of heavy rain continuing more than eight hours.

Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.
1872.								
Sept. 26–2	2·27	Mt. Washington.	26–3	1·20	Mt. Washington.			
28–3	2·02	Chicago.	29–1	1·31	Grand Haven.			
Oct. 25–1	3·41	Norfolk.	25–2	1·45	New York.			
Nov. 7–1	2·50	New York.	7–2	1·49	New London.			
1873.								
May 1–1	2·20	Nashville.	1–2	3·05	Montgomery.	1–3	1·80	New Orleans.
June 9–3	2·93	St. Louis.	10–1	1·07	St. Louis.	10–2	1·50	Indianapolis.
22–3	2·28	St. Paul.	23–1	2·30	St. Paul.			
July 16–1	2·10	Marquette.	16–2	2·45	Fort Garry.			
17–3	2·00	Buffalo.	18–1	1·05	Mt. Washington.			
27–2	2·12	Washington.	27–3	2·03	Philadelphia.			
Aug. 13–1	2·31	Philadelphia.	13–2	2·17	Philadelphia.	13–3	3·26	Baltimore.
Oct. 7–1	2·02	Portland, Me.	7–2	1·60	Eastport.			
19–3	2·25	New London.	20–1	1·96	Burlington.	20–2	1·38	Mt. Washington.

The average direction and force of the wind during these cases of heavy rain-fall both for the southern and northern stations was as follows:

		Direction.	Force.
South of latitude 36°.	At previous obs.	N. 79° E.	8·1
	at date,	N. 75° E.	9·9
North of latitude 36°.	At previous obs.	S. 69° E.	11·8
	at date,	S. 39° E.	11·3

We thus see that both at the northern and southern stations heavy rains are generally accompanied by easterly winds. At the northern stations southeast winds are most prevalent, while at the southern stations northeast winds are most prevalent. At the southern stations there are but eleven cases in which east winds are not reported either at date or at the preceding observation. These exceptions are Nos. 4, 10, 18, 20, 25, 28, 30, 34, 46, 48 and 50. In four of these cases the force of the wind was reported 0; in two of them it was reported as one mile per hour; in two cases it was four miles per hour; in one case it was five miles: in one case eight miles and in one case twelve miles per hour. We thus see that during a heavy rain-fall, the wind either blows from some eastern quarter, or its velocity is almost invariably small.

At the northern stations there are but eight cases in which east winds are not reported either at date or at the preceding observation. These exceptions are Nos. 2, 12, 16, 18, 20, 21, 28 and 29. Two of these cases occurred on the summit of Mt. Washington; in one of the remaining cases the velocity of the wind was 0; in one it was five miles per hour; in one it was seven miles; in two it was eight miles; and in one it was twelve miles per hour. We thus see that at the northern stations as well as at the southern, during a heavy rain-fall the wind blows from some eastern quarter, or its velocity is almost invariably small.

On Plate III are shown the curves of equal rain-fall for Sept. 23, 1872, being No. 1 of the table on page 15. The outer curve shows the extreme limits of the rain area and the other curves show the limits of a rain fall of one inch and of two inches. The arrows show the direction of the wind at 7 A. M., which was previous to the middle of the rain fall. There was a center of low pressure (29·35) near Omaha, which was about west of the center of the rain area and distant from it 660 miles. Near the Atlantic coast there was a belt of high pressure (30·25). The result of this unequal pressure was a general prevalence of southeast winds throughout a large part of the Mississippi valley. Northerly winds commenced blowing from the neighborhood of Lakes Superior and Huron, being the result of a lower temperature and a higher pressure. This colder wind from the north probably flowed under the southeast wind which had been blowing over Lake Michigan and produced that strong upward movement of the air which was followed by excessive rain at Grand Haven and Milwaukee.

In a large number of the cases in the table on page 15 the observations show that a southeast wind at certain stations was opposed by a westerly or northerly wind at other stations. This opposition or interference of winds generally results in a cycloidal movement, and the observations clearly indicate such a movement in nearly all of the cases in the table on page 15. When the rain area was remote from the center of low pressure this cycloidal movement was local and limited to a small area and did not generally exert a decided influence upon the isobaric curves.

In preparing the materials for this article I have been assisted by Mr. Edward S. Cowles, Ph.D., a graduate of Yale College of the class of 1873.

ART. II.—*On Some Points in Connection with Vegetation:* by DR. J. H. GILBERT.*

THE subject of vegetation is such a very wide one, and might be treated of in so many different ways, that it seems desirable to state at the outset what is the scope, and what are the limits, of the discussion which I propose to bring before you. I propose, then, to confine attention almost exclusively to the question of the *Sources of the nitrogen of vegetation in general, and of agricultural production in particular.* I propose further to treat of this subject mainly in the aspects in which it has forced itself upon the attention of Mr. Lawes and myself during the now thirty-three years of our agricultural investigations; and, also, in so far as it illustrates, and is illustrated by, the objects contributed by Mr. Lawes to the Exhibition around us.

Before entering upon the special subject matter of my discourse, I must claim the indulgence of those present, who are already well acquainted with the main facts of the chemistry of vegetation, while I call attention, very briefly, to some rather elementary matters, with a view of rendering what has to follow the more intelligible to any who may be less fully informed on the subject.

When a vegetable substance is burnt—as a familiar instance, let us say tobacco, for example—the greater part of it is dissipated, but there remains a white ash. The ashes of crude or unripe vegetable substances are found on analysis to contain most, or all, of the following constituents, namely:—

Oxide of iron, oxide of manganese, lime, magnesia, potass, soda, phosphoric acid, sulphuric acid, chlorine, and silica.

Rarer substances than these are also sometimes found. Now, much has of late years been established in regard to the occurrence, and the offices, of some of these substances in plants; but I do not propose to touch upon the questions herein involved. It will suffice further to say in regard to these incombustible, or "mineral" constituents, that the ash of one and the same description of plant, growing on different soils, may, so long as it is in the growing or immature state, differ very much in composition. Again, the ashes of different species, growing on the same soil, will differ very widely in the proportion of their several constituents. But it is found that the nearer we approach to the elaboration of the final products of the plant —the seed, for example—the more fixed is the composition of ash of such products of one and the same species. In other words, there is very little variation in the composition of the ash of one and the same description of seed, or other final product, provided it be evenly and perfectly matured. This fact alone, independently of all that has been established of late years in regard to the office or function, so to speak, of individual mineral constituents of plants, would be sufficient to indicate the essentialness of such constituents for healthy growth; and it is obvious that they must be provided *within the soil.*

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* An address delivered at South Kensington, in the Chemical Section of the Science Conferences, by Dr. J. H. Gilbert, F.R.S., F.L.S., F.C.S.

But now as to the combustible constituents—the carbon, the hydrogen, the oxygen, and the nitrogen. Leaving out of consideration such exceptional cases as those brought to light in Mr. Darwin's beautiful investigation on insectivorous plants, and also the sources of the organic substance of fungi, and perhaps of some forced horticultural productions, it may be stated, that the source of the carbon of vegetation generally is the carbonic acid existing in very small proportion, but in large actual amount, in the atmosphere; that the source of the hydrogen is water; and that the source of the oxygen may be either that in carbonic acid, or that in water. With regard to the nitrogen the case is, however, by no means so simple. Not that there are no questions still open for investigation in regard to the assimilation by plants of their incombustible or mineral constituents, or of their carbon, their hydrogen, and their oxygen; but those relating to the sources, and to the assimilation, of their nitrogon, are not only in many respects of more importance, but seem to involve greater difficulties in their solution.

What, then, are the sources of the nitrogen of vegetation? Are they the same for all descriptions of plants? Are they to be sought entirely in the soil? or entirely in the atmosphere? or partly in the one, and partly in the other?

Amount of nitrogen carried down by atmospheric precipitation.—As the combined nitrogen coming down from the atmosphere in rain, hail, snow, mists, fog, and dew, does undoubtedly contribute to the annual yield of nitrogen in our crops, let us first briefly consider what is known as to the amount of it annually so coming down over a given area of the earth's surface; and as we are here discussing the subject in England, I will adopt the English pound as the unit of weight, and the English acre as the unit of area. The following table shows the amount of nitrogen coming down as ammonia and nitric acid in the total rain, hail, snow, and some of the minor deposits, during the years 1853, 1855, and 1856, at Rothamsted (Herts), the nitric acid being in all cases determined by Mr. Way, and the ammonia in some cases by him, and in others by ourselves:—

TABLE I.—*Combined Nitrogen in Rain and Minor Aqueous Deposits at Rothamsted.*

	Nitrogen per acre, per annum, lbs.			
	1853.	1855.	1856.	Mean.
As ammonia	5·67	5·86	7·85	6·46
As nitric acid	(not determined)	0·77	0·73	0·75
Total		6·63	8·58	7·21

Numerous determinations of the ammonia and nitric acid in rain, and the other aqueous deposits, have been made in various parts of France and Germany, some in the vicinity of towns, and some in the open country. Of the latter, which are the most to our purpose, it may be stated that those of Boussingault at Liebfrauenberg, in Alsace, generally indicate a larger proportion of the nitrogen existing as nitric acid, and less as ammonia than our own; but, upon the whole, the observations in the two widely separated localities mutually confirm one another. Of the results of others, in other localities, some show about the same amount of combined nitrogen so deposited as our own, some, however, much more, and some much less, than ours; but the determinations on the Continent generally show a higher proportion of the total combined nitrogen to exist as nitrates than those in this country. It may be added, that numerous determinations of the combined nitrogen in rain, dew, etc., collected at Rothamsted, have much more recently been made by Professor Frankland, and his results, which are published in the "Sixth Report of the Rivers Pollution Commission," are substantially confirmatory of the earlier determinations, summarized in the foregoing Table, but upon the whole they indicate lower amounts. Lastly, M. Marié-Davy determined the ammonia in the rain, etc., collected at the Meteorological Observatory at Montsouris, Paris, during the last six months of 1875; and the amount of ammonia so coming down, even within the walls of Paris, represented only 5·25 lbs. of combined nitrogen per acre, or only 10·5 lbs. per acre, per annum. M. Marié-Davy did not make a complete series of determinations of the nitric acid in the meteoric waters, but his initiative results agree with the experiments of others in showing the amount of combined nitrogen to be comparatively small.

Thus, the determinations hitherto made of the amount of combined nitrogen coming down in the measured aqueous deposits from the atmosphere, do not justify us in assuming that the quantity available from that source will exceed eight or ten lbs. per acre, per annum, in the open country, in Western Europe. It should be observed, however, that the amount of ammonia especially is very much greater in a given volume of the minor aqueous deposits than it is in rain; and there can be little doubt that there would be more ammonia deposited from them within the pores of a given area of soil, than on an equal area of the non-porous even surface of a rain gauge. How much, however, would thus be available to the vegetation of a given area beyond that determined in the collected and measured aqueous deposits, we have not the means of estimating with any certainty. On the other hand, numerous independent determinations, by both Dr. Voelcker and Dr. Frankland, of the nitric acid in the drainage-water collected from land at Rothamsted which had been many years unmanured, lead to the conclusion that there may be a considerable annual loss of nitrogen by the soil in that way.

Amount of nitrogen derived by crops of different kinds when grown without manure.—The next point to consider is, what is the amount of nitrogen annually obtained over a given area, in different crops, when they are grown without any supply of it in manure. This point may be illustrated by the results obtained in the field experiments on Mr. Lawes' farm at Rothamsted, which have now been in progress for about a third

TABLE II.—*Yield of Nitrogen per acre, per annum, in Wheat, Barley, and Root Crops, at Rothamsted.*

Crop. &c.	Condition of Manuring, &c.		Duration of Experiment.	Average Nitrogen per acre, per annum.
				lbs.
Wheat.	Unmanured		8 yrs. 1844-'51	25·2
			12 yrs. 1852-'63	22·6
			12 yrs. 1864-'75	15·9
			24 yrs. 1852-'75	19·3
			32 yrs. 1844-'75	20·7
	Complex Mineral Manure		12 yrs. 1852-'63	27·0
			12 yrs. 1864-'75	17·2
			24 yrs. 1852-'75	22·1
Barley.	Unmanured		12 yrs. 1852-'63	22·0
			12 yrs. 1864-'75	14·6
			24 yrs. 1852-'75	18·3
	Complex Mineral Manure		12 yrs. 1852-'63	26·0
			12 yrs. 1864-'75	18·8
			24 yrs. 1852-'75	22·4
Root Crops.	Complex Mineral Manure.	Turnips	8 yrs. 1845-'52	42·0
		Barley	3 yrs. 1853-'55	24·3
		Turnips	15 yrs. 1856-'70*	18·5
		Sugar-beet	5 yrs. 1871-'75	13·1
		Total	31 yrs. 1845-'75	26·8

* Thirteen years' crop—two years failed.

of a century. Table II shows the yield of nitrogen per acre, per annum, in wheat, in barley, and in root crops, each grown for many years in succession on the same land, either without any manure, or with only a complex mineral manure, that is supplying no nitrogen.

Bearing in mind what has been said as to the amount of combined nitrogen known to be annually deposited from the atmosphere, the figures in Table II have great interest and significance. Thus, over a period of thirty-two years, the wheat has yielded an average of 20·7 lbs. of nitrogen, per acre, per annum, without manure. But if we look at the quantities yielded during the first eight, the next twelve, and the last twelve years of that period, it is seen that there has been a gradual, but at the same time a considerable decline in the annual yield. From this it would appear probable that the nitrogen of the soil derived from previous accumulations, is being gradually reduced. Whether or not the whole of the excess of yield over that available from the rain, and other measured aqueous deposits from the atmosphere, is due to previous accumulations within the soil, and is therefore inducing a gradual exhaustion of its stock of nitrogen to that extent, we have not conclusive evidence to show. Determinations of nitrogen in samples of the soil taken at different times during the course of the experiments do, indeed, show an appreciable reduction. It is probable, however, that a part of the excess of yield is due to condensation of ammonia within the pores of the soil, beyond that which would be deposited in rain, and in the dew and other minor deposits condensed on the non-porous even surface of a rain-gauge, as already referred to.

Excluding the first eight years of the growth of wheat, it is seen that while over the next twenty-four years, 1852–1875, the wheat yielded 19·3 lbs. of nitrogen, per acre, per annum; the barley yielded an average of 18·3 lbs. over the same period. Again, during the first twelve of the twenty-four years, the wheat yielded 22·6 lbs., and the barley 22 lbs.; while, during the second twelve years, the yield in wheat was reduced to 15·9, and that in the barley to 14·6 lbs. The similarity in the yield of nitrogen over the same periods in these two closely allied crops, growing in different fields, is very striking, though, upon the whole, the indication is that the autumn-sown wheat has accumulated more than the spring-sown barley.

It is next to be observed that the annual use of a complex mineral manure has but very slightly increased the yield of nitrogen in either of these gramineous crops; and it is probable that the increased yield, such as it is, is derived from the previous accumulations within the soil, and not from atmospheric sources.

To sum up the evidence in regard to the sources of the nitrogen of these two typical gramineous plants, when none of it is supplied to them by manure, though it is not conclusively shown whence the whole of it is derived, it would at any rate appear probable, that it may be accounted for by the combined nitrogen coming down in rain and in the other measured aqueous deposits from the atmosphere, by the condensation of the ammonia of the air within the pores of the soil, and by the previous accumulations within the soil.

Let us now consider what is the yield of nitrogen by plants of other natural families, and first of all by certain so-called "root-crops"—turnips of the natural order Cruciferæ, and sugar beet of the order Chenopodiaceæ. On this point we have the experience of thirty-one years, excepting that during three of those years barley was grown without any manure in order to equalise the condition of the land as far as possible before re-arranging the manuring, and during two other years the turnips failed and there was no crop.

It should be premised that when root-crops are grown without manure of any kind, there is after a few years scarcely any produce at all; and hence the results recorded in the table are those obtained by the use of mineral manures, but without any supply of nitrogen. It is seen that during the first eight years of turnips, there was an average yield of 42 lbs. of nitrogen per acre, per annum. During the next three years barley yielded 24·3 lbs. annually. During the next fifteen years, thirteen with Swedish turnips, and two without any crop, there was a yield of 18·5 lbs. per acre annually. During the last five years sugar-beet yielded 13·1 lbs. per acre, per annum Lastly, over the whole thirty-one years, during which there were three crops of barley, two years without any crop, twenty-one years of turnips, and five of sugar-beet, the average annual yield was 26·8 lbs. of nitrogen.

Here, then, we have a reduction to less than one-third during the later compared with the earlier years, and to a lower point than even with either wheat or barley; though, during the whole period, the annual yield is higher than with either of the two gramineous crops. It may be mentioned that we have other experimental evidence showing that the so-called "root-crops" exhaust at any rate the superficial layers of the soil of their available supplies of nitrogen, more completely than perhaps any other crop. It may further be added that the surface soil has shown during recent years a lower percentage of nitrogen than that of any of the other experimental fields. We have fair grounds for concluding, therefore, that if in the cases of the wheat and the barley the nitrogen yielded beyond that retained by the soil from the direct measurable aqueous deposits, together with that condensed within the pores of the soil from the atmosphere, be derived from previous accumulations within the soil, so also may the excess of yield by the so-called "root-crops" be accounted for.

We now come to the consideration of the yield of nitrogen when plants of the *leguminous* family are separately grown, or when they, and plants of some other families, are grown in alternation, or in association, with the Gramineæ. Table III shows the results obtained with beans, and with clover; with clover and barley grown in alternation; and with turnips, barley, clover or beans, and wheat, grown in an actual course of rotation.

TABLE III.—*Yield of Nitrogen per acre, per annum in Beans, in Red Clover, and in Rotation.*

Crops, &c.	Conditions of Manuring, &c.		Duration of Experiment.	Average Nitrogen per acre, per annum.
				lbs.
Beans	Unmanured		12 yrs. 1847-'58	48·1
			12 yrs. 1859-'70(*)	14·6
			24 yrs. 1847-'70	31·3
	Complex Mineral Manure		12 yrs. 1847-'58	61·5
			12 yrs. 1859-'70(*)	29·5
			24 yrs. 1847-'70	45·5
Clover	Unmanured		22 yrs. 1849-'70(†)	30·5
	Complex Mineral Manure		22 yrs. 1849-'70(†)	39·8
Barley	Unmanured		1 yr. 1873	37·3
Clover			1 yr. 1873	151·3
Barley	Unmanured	After Barley	1 yr. 1874	39·1
		After Clover	1 yr. 1874	69·4
	Barley after Clover more than after Barley			30·3
Rotation 7 Courses	1 Turnips 2 Barley 3 Clover or Beans 4 Wheat	Unmanured	28 yrs. 1848-'75	36·8
		Superphosphate	28 yrs. 1847-'75	45·2

Referring first to the results obtained with beans the table shows that without manure there was an annual yield over the first twelve years, 1847–1858, of 48·1 lbs. of nitrogen. Over the next twelve years, 1859–1870, it was reduced to 14·6 lbs. per acre, per annum. Still, over the whole period of twenty-four years, we have an annual yield of 31·3 lbs., or more than one and a half time as much as in either wheat or barley.

(*) Nine years Beans, one year Wheat, two years fallow.
(†) Six years Clover, one year Wheat, three years Barley, twelve years fallow.

In the case of wheat and barley it was seen that a mixed mineral manure increased the yield of nitrogen to a very small degree only. Not so in the case of the leguminous crop, beans. During the first twelve years a complex mineral manure, containing a large amount of potass—I call attention to this fact because we have abundant evidence that it is the potass chiefly that is effective—gave 61·5 lbs. of nitrogen per acre per annum against 48·1 lbs. obtained over the same period without manure. During the next twelve years, the potass manure gave 29·5 lbs. against scarcely half as much, or 14·6 lbs. without the potass manure. And finally, during the whole period of twenty-four years, the potass manure has given 45·5 lbs. of nitrogen per acre, per annum, against 31·3 lbs., or only about two thirds as much, without manure; and we have more than twice as much yielded by a potass manure over a period of twenty-four years with beans than with either wheat or barley.

Before calling attention to the figures relating to another leguminous crop—red clover—it should be mentioned that leguminous crops generally are, and clover in particular is, extremely sensitive to adverse climatal circumstances; but clover is pre eminently sensitive to soil conditions also. Indeed, it is a fact well recognized in agriculture, that few soils can be relied upon to grow a good crop of clover oftener than once in about eight years; and many soils will not yield it so frequently. It will not excite surprise, therefore, that in attempting to grow clover year after year on the same land, we have only succeeded in getting any crops, and some of those poor ones, in six years over a period of twenty-two. Indeed, the plant failed seven times out of eight during the winter and spring succeeding the sowing of the seed; when, in some cases a crop of wheat or barley was taken, and in others the land was left fallow. Hence, over a period of twenty-two years we have had only six years of clover, one of wheat, three of barley, and twelve of fallow. Still, the annual yield of nitrogen over the twenty-two years was 30·5 lbs. without any manure, and 39·8 lbs., or nearly one third more, by mineral manure containing potass. Unfavorable as was this experiment in an agricultural point of view, still it is seen that the influence of the interpolation of this leguminous crop has greatly increased the yield of nitrogen compared with that obtained in either wheat or barley grown continuously; and that, unlike the result with those crops, a potass manure has here again, as with beans, greatly increased the yield.

Without attempting for the moment to discuss the probable source or sources of this greatly increased yield of nitrogen by leguminous as compared with gramineous crops, I will simply here remark in passing that we have no evidence leading to the conclusion that this increased assimilation is at the expense of the nitrogen existing at any rate in the upper layers of the soil. In fact, such initiative results as we have relating to the nitrogen in the soil of the experimental bean field, would rather lead to the conclusion that the better the crop has grown, and the more nitrogen it has assimilated, the richer rather than the poorer in nitrogen (as indicated by the soda-lime method) has the surface soil become. To this point, however. we shall have to recur presently; but in the meantime let us first refer to the yield of nitrogen in other cases in which leguminous crops have been interpolated with others.

It is, indeed, well known that the growth and removal of a highly nitrogenous leguminous crop is one of the best possible preparations for the growth of a gramineous corn crop, which characteristically requires nitrogenous manuring. A striking illustration of this apparent anomaly is afforded in the results next in order recorded in Table III.

After the growth of six corn crops in succession by artificial manures alone, barley was grown without manure in 1873 on one portion of the same land; and on another portion clover was grown. It is calculated that there were taken off in the barley 37·3 lbs. of nitrogen, and in the three cuttings of clover 151·3 lbs. Yet, in the next year, 1874, barley succeeding the barley gave 39·1 lbs., and barley succeeding the clover gave 69·4 lbs. of nitrogen; or 30·3 lbs. more after the removal of 151·3 lbs. in clover than after the removal of 37·3 lbs. in barley. Nor was this remarkable result to be explained by either accident or error. For, determinations of nitrogen in four separately taken samples of the soil, in the mixture of the four, and in the mixture of six others, taken from each plot, and at different depths, all concurred in showing an appreciably higher percentage of nitrogen, especially in the surface soil, nine inches deep, of the land from which the clover had been removed than in that from which the barley had been taken; and this was so, although, in every case, all visible vegetable debris had been carefully picked out. Here, then, the surface soil at any rate was positively enriched in nitrogen (determinable by soda lime) by the growth and removal of a very highly nitrogenous crop. It may be mentioned that Dr. Voelcker has obtained results of a similar character.

The results next to be considered are those obtained in an actual four-course rotation of crops—namely, turnips, barley, clover or beans, and wheat. The experiments have been conducted through seven such courses; that is to say, over a period of twenty-eight years. One portion of the land, the results relating to which are given in the table, has been entirely unmanured during the whole of that period, and the other has received super-phosphate of lime alone, once every four years —that is to say, for the turnips commencing each course; but it has received no other manure throughout the twenty-eight years, either mineral or nitrogenous.

Under these conditions—that is with a turnip crop and a leguminous crop interpolated with two gramineous crops—we have, without manure of any kind, an average of 36·8 lbs. of nitrogen yielded per acre, per annum; or not far from twice as much as was obtained with either of those cereal crops, wheat or barley, grown consecutively. With super-phosphate of lime alone, which, in a striking degree increased the yield of nitrogen in the turnips, reduced it in the succeeding barley, increased it greatly in the leguminous crops, and slightly in the wheat immediately following them, we have the average annual yield of nitrogen raised to 45·2 lbs. per acre, per annum, over the twenty-eight years; or to more than double that obtained by wheat or barley grown continuously by mineral manures alone. And it may be observed that where, in adjoining experiments, no leguminous crop was grown between the barley and the wheat, but the land was fallowed instead, the total yield of nitrogen in the rotation was very much less: the wheat succeeding the fallow yielding very little more nitogen than that succeeding the leguminous crops which had removed so much of it. In other words, the removal of the most highly nitrogenous crops of the rotation— beans or clover—has been succeeded by a growth of wheat, and assimilation of nitrogen by it, almost as great as when it has succeeded a year of fallow—that is to say, a period of accumulation from external sources, and no removal by crops.

One other illustration must be given of the power of plants of the leguminous and some other families to assimilate more nitrogen over a given area than those of the gramineous family. But before entering upon the bearing of the results in question on this particular point, it will be necessary to digress a little to call special attention to the conditions of the experiments under which the results were obtained; and it is the more desirable to do this, since the most important of Mr. Lawes' contributions to this Exhibition is an illustration of the results I am about to refer to.

Effects of manure.—I must here forestall a little what I shall have to refer to more fully further on, as to the effects of characteristically different substances on crops belonging to different botanical families. I will say briefly, then, that it is found that nitrogenous manures have generally a very striking effect in increasing the growth of gramineous crops grown separately on arable land, such as wheat, barley, or oats, all of which contain a comparatively small percentage of nitrogen, and, as has been illustrated, assimilate a comparatively small amount of it·

over a given area when none is supplied to them in manure. The highly nitrogenous leguminous crops, on the other hand, such as peas, beans, clover, and others, are by no means characteristically benefitted by the use of direct nitrogenous manures, such as ammonia-salts or nitrates, though nitrates act much more favorably than ammonia-salts. Again, while, under equal conditions of soil and seasons, mineral without nitrogenous manures increase comparatively little the poor-in-nitrogen gramineous crops that are grown separately, such manures, and especially potass-manures, as has been seen, increase in a striking degree, the growth of crops of the leguminous family grown separately, and coincidently the amount of nitrogen they assimilate over a given area.

Such, then, is the result obtained in the separate growth, on arable land, of individual plants of the different families. Now, in the mixed herbage of permanent grass land, we may have fifty, or even many more species growing together, representing nearly as many genera, and perhaps eighteen or twenty natural orders or families. Of these, the Gramineæ generally contribute the largest portion of the herbage; and, on good grass land, if the Leguminosæ do not come second, they are at any rate prominent. The degree in which other orders are represented may be very various indeed, according to soil, locality, season, and other circumstances. In Mr. Lawes' park, at Rothamsted, nearly eighty species have been observed; but of many only isolated specimens, and it may be stated generally that about fifty species are so prominent as to be found in a carefully averaged sample of the hay grown without manure.

Experiments on the influence of different manures on this mixed herbage were commenced in 1856: at which time the herbage was apparently pretty uniform over the whole area selected. About twenty plots, from one-quarter to one-half an acre each, were marked out, of which two have been left continuously without manure, and each of the others has received its own special manure, and as a rule the same description year after year—and the experiments have now been conducted over a period of twenty years.

Under this varied treatment, changes in the flora, so to speak, became apparent even in the first years of the experiments; and three times since their commencement, at intervals of five years—namely, in 1862, 1867, and 1872—a carefully averaged sample of the produce of each plot has been taken and submitted to careful botanical separation, and the percentage, *by weight*, of each species in the mixed herbage determined. Partial separations have also been made in other years.

Mr. Lawes has contributed a large case of specimens to the exhibition, which shows the botanical composition of the herbage on selected plots in the seventeenth season of the experiments (1872). The quantities of the different plants there exhibited represent the relative proportion, by weight, in which each species was found in the mixed produce of the different plots; and the whole illustrates in a striking manner the domination of one plant over another, under the influence of different manures, applied year after year on the same plot.

The general results of the experiments may be briefly summarized as follows:—

The mean produce of hay per acre per annum has ranged, on the different plots, from about twenty-three cwt. without manure to about sixty-four cwt. on the plot the most heavily manured.

The number of species found has generally been about fifty on the unmanured plots, and has been reduced to an average of only twenty, and has sometimes been less, on the most heavily manured plots.

Species belonging to the order *Gramineæ* have, on the average, contributed about sixty-eight per cent of the weight of the mixed herbage grown without manure; about sixty-five per cent of that grown by purely mineral manures (that is, without nitrogen); and about ninety-four per cent of that grown by the same mineral manures, with a large quantity of ammonia-salts in addition.

Species of the order *Leguminosæ* have, on the average, contributed about nine per cent of the produce without manure, about twenty per cent of that by purely mineral manures (containing potass), and less than 0·01 per cent of that by the mixture of the same mineral manures and a large quantity of ammoniacal salts.

Species belonging to various other orders have, on the average, contributed about twenty-three per cent of the produce without manure; about fifteen per cent of that by purely mineral manures, and only about six per cent of that by the mixture of the mineral manures and a large amount of ammonia-salts.

Not only the amounts of produce, but the number and description of the species developed, have varied very greatly between the extremes here quoted, according to the particular character or combination of manure employed, and to the character of the seasons, as is strikingly illustrated by the arrangement of the specimens in the case, which, however, it should be borne in mind, show the composition of the herbage on the selected plots in one particular season only—namely, in 1872.

Obviously, these few remarks can only very inadequately indicate the interest of these curious illustrations of the domination of one plant over another in the mixed herbage of permanent grass land. Nor do we pretend to be able to give a satisfactory explanation of the variations induced, founded on the obvious or recorded difference in above-ground or underground character or habit of growth of the individual species. The whole of the results—agricultural, chemical, and botanical—obtained during the twenty years of the experiments are, however, now in course of arrangement for publication; and that we may not overlook such explanations as might be suggested from the point of view of the botanist and vegetable physiologist, as well as that of the chemist, we have associated with ourselves Dr. Masters in working up the botanical part of the inquiry; and I think Dr. Masters will agree with me in saying that much more has yet to be known of the difference in the physiological capability, so to speak, of the leaves of plants of different species, genera, and orders, and of the difference in the distribution, and in the feeding power, of the roots, before satisfactory explanations of the facts observed can be given. Surely, a wide field of investigation for the botanist and vegetable physiologist is here opened up to view!

(To be continued.)

ART. III.—*Observations on a property of the Retina, first noticed by Tait;* by OGDEN N. ROOD, Professor of Physics in Columbia College.

IN the Edinburgh Proceedings, 1869–70, vii. p. 605–607, Tait described an interesting observation, which has perhaps some bearing on Thomas Young's theory of color. While suffering from indisposition, he noticed each time on awakening from a feverish sleep, that the flame of a lamp seen through a ground-glass shade, assumed a deep red color, the effect lasting about a second. He suggests that the nerve fibrils in the retina also partook of sleep, and on awakening the green and violet nerves resumed their function somewhat later than the red. I have in my own case noticed some instances, which seem to point out that after a *nervous shock*, sudden or prolonged, the green nerves (adopting the theory of Young,) recover their activity later than the red, and probably later than the violet nerves. The first observation was made twenty years ago while recovering from the effects of chloroform, which had been administered by a dentist, well known at that time in Munich. Upon regaining consciousness, and raising my eyes to the face of the operator, I was a little surprised at not having previously remarked his unusually ruddy complexion, but the next instant saw that this was due to an optical illusion, for his hair appeared of a bright purplish-red hue. The singular appearance lasted perhaps a couple of seconds, when his hair resumed its natural color, which was *white*. This observation corresponds with that made by Tait.

I give now an instance, where chronic effects of a similar character were noticed by me for a couple of weeks continuously, during convalescence from typhoid fever. In this case white objects appeared of a not very intense orange-yellow hue, the general effect on a landscape being such as is produced by the orange-yellow rays of the setting sun. Here the activity of the green and violet nerves was diminished relatively to that of the red. The auditory nerve was also evidently affected during the same period, but precisely in what way I did not ascertain.

It is a matter of yearly observation with me, that effects, similar in kind with those first noticed, are produced by prolonged exposure to bright white light out of doors. Under such circumstances white objects no longer appear pure white, but are tinted plainly purplish-red, and rather dull greens assume a gray hue, as though all the green in them had been neutralized, while strong greens are considerably reduced in intensity (saturation.) Upon leaving the blinding glare and entering a darkened room, it often for several seconds appears filled with a greenish haze.

Two of these cases and, probably that of Tait, point out, that our apparatus for the reception of waves of light of medium length, is more liable to be over-strained by nervous shocks or by prolonged excitation, than is the case with those designed for the reception of waves of greater or lesser length. Nervous derangement and prolonged excitation, are then causes, which may produce temporary green color-blindness.

ART. IV.—*On grains of Metallic Iron in Dolerytes from New Hampshire;* by GEORGE W. HAWES.

THE presence of metallic iron in certain basalts and dolerytes has been repeatedly proved. It was first shown by Dr. Andrews that it was contained in the basalts of the Giant's Causeway.* Reuss has proved its presence in Bohemian basalts; and in this country it has been found in the Mesozoic dolerytes of New Jersey by Cook.†

In all these cases the iron has been detected by a microchemical method. If a portion of a rock is pulverized, and the magnetic constituents withdrawn by passing a magnet over the powder, any metallic iron which may be present in the rock can be recognized by treating this magnetic portion with an acid solution of sulphate of copper and then examining it with the microscope to see if any metallic copper is precipitated. If metallic iron is present it exchanges places with the copper, and crystalline aggregates of metallic copper, easily recognizable by their color and luster, will be seen. But as Dr. Andrews remarked in speaking of the Ovifak iron, in his inaugural address before the British Association last summer, it has never been found possible to detect with the microscope this iron which was known to be present. It is proposed here to point out the mode of occurrence of visible grains of metallic iron in dolerytes from New Hampshire.

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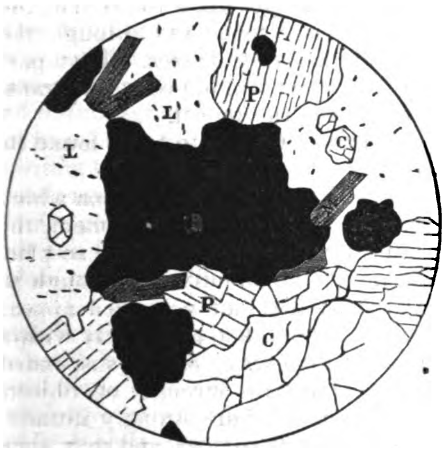
* Pogg. Ann., 1853, Bd. 88, p. 321.

† Cook, Annual Report of State Geol. Survey for 1874, p. 56.

Upon the Dry river, a small stream which gathers its waters from Mount Washington, there are numerous large dikes of chrysolitic doleryte, which cut through the old crystalline rocks. These dolerytes are composed of labradorite, pyroxene, chrysolite and magnetite, with a little mica; and, though they contain such decomposable materials, the rocks are remarkably fresh, and all the minerals are clear when looked at in thin sections with the microscope, showing no signs of alteration. This may be due in part to the remarkable compactness of the rock, and perhaps more to the great freshets in the spring time, which remove any soft or loose material.

Considering that the circumstances would be favorable for the preservation of metallic iron in these rocks if any were originally present, I tested for it according to the method before described, and the strength of the reaction was surprising. The magnetic constituents treated with sulphate of copper exhibited numerous bright crystalline aggregations of copper which were plainly visible to the naked eye. The reaction was so much more marked than any that I had obtained in testing the trap rocks of the Connecticut valley, which contain iron when not altered by decomposition, that I examined the sections to ascertain if it could not be seen under the microscope; and I found on shutting off the light from the mirror below and examining them with light reflected only from the section, that a few of the grains of magnetite possessed a bright metallic center, which had the luster of metallic iron, and which was very marked in the bluish-black magnetite. Taking an unmounted section which possessed one of these grains near its center, I treated it with sulphate of copper, when the grain was covered with a coat of copper, proving it to be iron. The following figure is drawn from a section of the rock, and represents it as magnified thirty five diameters. The black mineral is magnetite, and the light colored spot in the large grain is the metallic iron. The other minerals of the slice are as follows: The white mineral with no cleavage but with irregular fractures is chrysolite (C); the mineral showing an interrupted cleavage is pyroxene (P); the shaded mineral with a perfect cleavage is black mica (M); and the white mineral which is clear and shows only a few impurities is labradorite (L). The chrysolite and biotite show an attempt at regular crystallization, while the other ingredients do not possess any regular external form, but the labradorite is finely striated by twinning, and this produces a beautiful effect when it is examined with polarized light. The magnetite is extremely magnetic, and, on being separated from the other material by a magnet, the grains retain magnetism and become little lodestones, and several quite large grains can be drawn along together with the end of a platinum wire. These rocks form a part of the series that will be described in the third part of the report of the New Hampshire Geological survey.



It has been supposed that the metallic iron of basalts results from the agency of carbon or some reducing agent, which acting on the magnetic iron at a high temperature has reduced a portion of it to the metallic state. The presence of this iron in the centers of the irregular grains of magnetite seems to indicate that the magnetite in this rock may have resulted from the oxidation of the iron.

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ART. V.—*On certain Phenomena of Binocular Vision*;* by FRANCIS E. NIPHER.

IT is possible that the phenomena here described may have been observed before, but I have been unable to find any record of them.

1. Fold a sheet of writing paper into a tube about an inch in diameter. Look through the tube at some distant object

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[*] **Read before the St. Louis Academy of Science, Nov. 6th, 1876.**

with one eye, and toward the open hand with the other eye, the edge of the hand being in contact with the tube. The dissimilar objects producing unlike images upon the retinæ, the sensations blend and a hole will appear to be cut through the palm of the hand, through which the tube passes. That part of the tube between the eye and hand will appear to be transparent, as though the hand were seen through it.

This experiment is very old, but seems not to have found its way into scientific literature.

2. Replace the hand by a sheet of unruled paper, upon which a drop of ink has been placed. By proper management, the ink blot may be made to appear within the tube, by so placing the paper that the hole which is apparently cut through it, coincides with the blot. Ordinarily the blot will then appear opaque, the paper immediately around it, and apparently within the tube, being invisible. The blot appears as it were suspended in space. By concentrating the attention strongly on objects seen through the tube, especially if they are strongly illuminated, the blot becomes more hazy, transparent, and may even be made to disappear altogether. The mental effort necessary to do this cannot be maintained more than a few seconds, and the spot will reappear. If the effort to cause the spot to thus disappear be kept up, the attention being strained to its highest pitch, the blot will disappear and reappear at regular intervals of a few seconds, the absolute time depending upon the illumination. It seems as though the organs exerted become fatigued, and relaxing for a few moments, refreshment sets in, which again renders possible the exertion necessary in causing the blot to disappear. It is possible that these experiments may be so made as to throw some light upon the conditions necessary in fixing the attention. Interesting experiments may also be made by substituting a fragment of a plane mirror for the sheet of paper. Looking through a rather large tube at a distant object with the right eye, and the reflected image of the left eye will appear staring up the tube, the adjoining parts of the head being invisible.

3. Substituting for the ink-blot a small hole cut through the paper, the small hole can also be made to appear within the tube, distinguishing itself by its different illumination, the surrounding paper being invisible, unless attention be directed too strongly to the paper in which the hole is cut. The relative illumination of the small hole, and the space immediately around it depends upon the relative illumination of objects upon which the tube is directed, and that of the sheet of paper exposed to the other eye.

4. Keeping the same arrangement, place at a distance of one foot from the end of the tube a sheet of paper so that objects

beyond it are still visible—arrange matters so that it is visible to the eye looking through the tube, but not to the other, directed at the small hole in the paper sheet. This second sheet will now appear to be traversed by a hole the same in size as that cut through sheet No. 1.

Cutting a small hole in sheet No. 2, matters are easily arranged so that it appears within the hole which was before seen within the tube. These experiments may be utilized in showing the simultaneous accommodation of the two eyes.

5. Tubes of this kind, blackened on the inside are very convenient in studying color sensations. Using two such tubes, look through one with the right eye, say, at red, through the other with the left eye at green paper, illuminated by the direct solar ray. The color sensations fade with marvelous quickness. Transferring both eyes to either color, say red, the eye fatigued by green sees the red greatly intensified, the effect being rendered the more striking by the simultaneous impressions received by the two eyes. Experiments in the combination of color sensations will readily suggest themselves.

The editor of the *Scientific American* has written something quite similar to some parts of this communication (Oct. 14), but a comparison of it with my short note in *Nature*, Aug. 10th, will show that I am not the borrower.

ART. VI.—*Notes on the Vespertine Strata of Virginia and West Virginia*; by WILLIAM M. FONTAINE.

Structure and geographical distribution.

THE eastern border of the unbroken area occupied by the Vespertine in the two Virginias may be taken as limited by the Main Alleghany, in the northern and middle portions of the area in question, and in the southern portion, by Peter's and East River Mountains.

As Prof. Wm. B. Rogers has shown, the rocks of the Vespertine, or No. X, compose the middle portion of the Main Alleghany from the Potomac to Pocahontas county. This range of mountains, for some distance south of the Potomac, is called "the Eastern Front Ridge of the Alleghany," while from the northern part of Pendleton county to the southeastern corner of Greenbrier county, it bears the name "Alleghany."

North of Pocahontas, according to Prof. Rogers, the range shows principally monoclinal westerly dips. The flexures here are comparatively broad and gentle. Hence the Vespertine and associated strata first dip gently westward, and then pass into a series of undulations, which extend nearly to the Ohio

River, declining more and more in abruptness. Owing to the increasing depth to which they are buried, the Vespertine strata are rarely brought to the surface in that direction by the flexures.

As we go south of Pocahontas the westward thrust which has affected this region, causes an increased elevation and flexing of the rocks. The structure of the Alleghany passes from monoclinal to anticlinal, with increasing steepness of dip, so that, in the vicinity of the White Sulphur Springs, where penetrated by the tunnel for the Chesapeake & Ohio Railroad, the strata stand nearly vertical.

Lower and lower rocks enter into its composition, in passing southward. As Rogers has shown, in the north, where monoclinal dips prevail, the lowest rocks seen in the east face of the mountain are those of No. IX or Catskill?. But near the White Sulphur, the core of the mountain is composed of the lowest Chemung, and, probably, Hamilton strata.

The development of an anticlinal structure, with increasing steepness of dip in passing southward, has had the effect of causing a belt of Vespertine rocks to be brought down on the east side of the mountain, and caught in a synclinal fold. This gives us the small coal beds seen near the Lewis Tunnel. At the same time the increase in the elevation and flexing of the strata southward from the northern part of Pocahontas county has brought up rocks lower than the Catskill?, not only in the Alleghany but over a belt about ten miles wide to the west, so that the east limit of the unbroken Vespertine, is thrown off to the western side of this area.

This belt shows strata all the way in the series, from the Oriskany to the Vespertine. The former barely appears in the lowest eroded places, and the latter shows merely small uneroded remnants of its lower portion. In the vicinity of the White Sulphur Springs, the strata throughout this area seem to be disposed in closed and contorted anticlinals overturned to the westward, which are separated by comparatively broad belts, in which the beds show moderately steep dips.

This disturbed belt is separated by a line of fault from the Vespertine strata. Here the transition is very abrupt, to a region which shows remarkably little disturbance. Prof. Rogers' description of the geology of the eastern corner of Monroe county would seem to show that the elevation of strata lower than the Vespertine in the Alleghany, and the belt to the west of it, is not maintained beyond the northeastern border of this county; for there we find that the eastern outcrop of the Vespertine area has closed in upon the Alleghany, while within the county this mountain chain is continued in Little Mountain, which is composed of upturned Vespertine strata.

With this disappearance of the elevated belt of disturbed Devonian strata, the fault which bounded it on the west also vanishes, but is succeeded by a much more important one, which begins some distance to the east of the termination of the Alleghany, in the northeastern edge of Monroe county. The rapid increase in the magnitude of this fault to the southwest soon swallows down the Devonian beds of the Alleghany, with their overlying bands of Vespertine coal beds, and brings the eastern outcrop of the Vespertine close to Lower Silurian strata. This fault, which runs not far to the west of Peters's and East River Mountains, bounds the Vespertine outcrop in that direction.

Every observer who has examined the structure of the country to the east and west of this fault, in the region extending from Monroe county to the southwest, has been struck with the remarkable difference in the amount of disturbance exhibited by the strata on the opposite sides of it. Prof. Lesley has given an excellent account of the condition of the country to the southeast of the fault above mentioned. The entire area here has been fractured, displaced, and folded, showing a truly astonishing amount of disturbance. On the northwest, or western side, we find the beds sometimes with their edges upturned, but they pass into an almost horizontal position in a short distance to the west. This is well shown in Prof. Lesley's section of Stone Mountain, where the conglomerate series is thus affected. Prof. Rogers, in his section of the strata in the northeast corner of Monroe county, gives a good example of this condition of things. Here the partially overturned beds of the Vespertine and Umbral, lying in the immediate vicinity of the fault, rapidly come down to nearly a horizontal position. In my account of the section near Greenbrier River, a similar structure will be shown. But here the line of fault separating the disturbed from the undisturbed region, is a minor one, developed by the rise of the Devonian belt near the White Sulphur Springs.

While the direction of this fault is thrown more in a northerly direction, and hence farther to the west than that of the one above described, yet it occupies the same relative position, and performs the same office, viz: that of checking the propagation of the disturbance through the strata to the west of it. This fault does not seem to continue far north, certainly not beyond Pocahontas county.

The country everywhere to the west of these last lines of fault, from Greenbrier county nearly to the Tennessee line, with the exception of a few undulations and disturbances in the vicinity of the fault, shows a prevailing northwest dip, as far as the Ohio River, which, as we go in that direction, brings us upon higher and higher strata. This region may then be regarded as an eroded plateau, sloping from the east toward the Ohio River. The mountains laid down as existing in this region are simply uneroded remnants of higher and softer strata, resting upon a basal plane, formed by lower and harder ones, such as the Lower Carboniferous Limestone, and the sandstones of the Conglomerate Series.

I have attempted to give some account of the topography of this part of the State of West Virginia, in the "Resources of West Virginia," recently published under the direction of the "State Board of Centennial managers."

North of Pocahontas county the flexures along the east border show no fault, but are propagated with diminishing force far to the west. In this quarter the most westerly fault is the great one, running along the west side of the great Lower Silurian limestone valley of Virginia. The Professors Rogers, in their discussion of the structure of the Appalachian Belt in the Virginias, have well shown the gradation of folds, in the northern part of the area in question, into faults in the southern part. In passing south the anticlinals become closed, then overturned to the west, and finally fractured. This feature is shown, as I have explained above, in the Devonian area near the White Sulphur.

An inspection of the map of the Virginias will show that the straight mountain chains which extend from the southern part of the two states in a northeasterly direction to the northeastern corner of Monroe county, are then thrown farther west, and made to take a north-northeasterly direction. The more southerly chains are produced by resistant strata, brought up along lines of fault, the more northerly, by folds.

The following seems to me to be the course of events, which resulted in the production of the present structure of the country:

The westward thrust, which, at the close of the Carboniferous Age, uplifted the Appalachian Belt, found the strata along its present western border, for some distance south of the Potomac, with their power of resistance comparatively unimpaired by any previously existing tension. Consequently, the undulations arising from the thrust were propagated far to the west. But to the south the case was different. The western edge was already weakened by the tension produced by the development of the deep trough, in which the lower Carboniferous strata were deposited, and this tension increased with the increased depth of this trough to the south. Hence, we find first the development of a minor fault along the eastern side of Greenbrier county, which relieved the strata to the west of it, in a great measure, from the westward thrust.

Passing south, into still more weakened strata, the sudden development of the great fault near the Sweet Springs, in Monroe county, to the east of the southerly prolongation of the Alleghany, in like manner relieves the country to the west from the upheaving force, causing the Alleghany, and the contorted belt on its west, to disappear, and the mountain chains to assume a more easterly course. From this point southward, in the region of greatest tension, the fractures are more profound and numerous. Any residual impulse, unrelieved by the faults, seems to have been exhausted in producing flexures in the immediate vicinity to the west of the fault, and in raising the eastern border of the great coal field as a whole, producing a gentle westerly dip toward the Ohio.

No doubt the great freedom of this area, thus tilted, from flexures of any magnitude, is due in part to the great development of massive sandstones in the lower Vespertine, and in the conglomerate series in this section, which would produce great rigidity.

A somewhat detailed explanation of the connection supposed to exist between the faulted and folded portions of the country, and the deep trough occupied by the lower strata of Carboniferous age, has been given in the above named "Resources of West Virginia," in the chapter by Mr. Maury on the "Coal Field of West Virginia."

The Vespertine strata occurring to the east of the limit mentioned at the beginning of this article, are found in detached belts and patches, mostly of small extent. As might be expected, from the above account of the structure of the country, in the northern and middle portions, they occupy usually the lower parts of synclinal folds, while in the southern portion, they are confined to the vicinity of faults. In each case they are more commonly found along the flank, or at the foot of a mountain, formed by the more resistant lower portion of the Vespertine, or underlying strata.

The following are the more important of these belts, and the only ones which I propose to notice, since they may be taken as true representatives of all the areas to be found in the region where they exist.

1. The belt mentioned above, as occurring on the east flank of the Alleghany Mountain, near the White Sulphur Springs. This belt contains the coal strata and plant impressions seen at Lewis Tunnel. It is especially instructive, since it shows the strata lying immediately above the Chemung, as well as the junction of these last with the lower portion of the Vespertine. All the strata here are well exposed in the deep cuttings for the Chesapeake & Ohio R. R.

This belt extends an unknown distance north of the railroad, probably to the northern part of Bath county. To the south, it terminates near the northeastern border of Monroe county. It occupies the bottom of a synclinal fold, and possesses but small width.

2. A much more extended and important belt, which lies about thirty miles east of the last. This commences in the northern part of Virginia, in the western part of Berkeley county, and extends thence south through the State, with some minor interruptions. It lies on the west side of the great Lower Silurian limestone valley, and close to the great fault which bounds it in that direction. In the northern and middle portions, the coal-bearing member of the Vespertine lies under the inverted massive sandstones of the lower member, and hence is found on the west side of the mountains, formed of this massive portion. In this part of the State, these mountains bear the names of "Great," and "Little," "North Mountain."

In the southern part of the State, the Vespertine strata are not inverted, but dip toward the fault. Hence in "Brush Mountain," the southern continuation of "North Mountain," the coal-bearing member lies on the southeastern face of the mountain. The great number of faults in this section has caused a small remnant to be caught and preserved, even within the area of the Silurian strata, as in the remarkable coal field of Price's Mountain, near Christiansburg in Montgomery county. I have been informed that coal has been discovered still farther to the east, within the limestone area, in the north end of Lick Mountain, in Wythe county. If this is true, it is without doubt Vespertine coal.

From the fact that all the strata, and the coals as well, thicken as we go east, it cannot be doubted that the Vespertine coal field extended considerably farther in that direction than any remnant now remaining. Leaving out of consideration the extension of these strata northward, into Pennsylvania, where they have been shown to contain coal beds, the area of the coal formation of this age, in Virginia and West Virginia, was by no means small. Judging only by the exposures which now remain, the belt of country over which well defined coal beds were formed, was more than 300 miles long, and fifty miles wide.

I have examined the exposures on the Greenbrier River, and at Lewis Tunnel, in the vicinity of the White Sulphur Springs, as well as those in the western edge of Augusta and Rockingham counties in Virginia, and in Montgomery county. I will give in the remainder of this article, some of the facts observed at these points.

The strata from the top of the Chemung to the base of the "Productive coals," in the two Virginias, pass into each other so gradually, that, in subdividing this great mass of sediment, one is forced to select the dividing planes somewhat arbitrarily, and to take for his guide, physical changes in the strata. The most natural horizon, to select as the upper boundary of the Vespertine in the Virginias, as it seems to me, is the base of the "Lewisburg," or "Lower Carboniferous Limestone." Yet, as we proceed north into Pennsylvania, this rock is absent. This is also the case in the eastern exposures in Virginia. Along the Greenbrier River there are certain red beds, underlying the limestone in question, and resting on the coal-bearing member of the Vespertine. Professor Wm. B. Rogers, if I understand his measurements correctly, places these in his Umbral, or No. XI, as he does the Lower Carboniferous Limestone, here exposed. There are two objections to this, I think. The physical character and composition of these red beds assign them more naturally to the Vespertine than to the limestone.

Another, and more important objection is, that if the lowest of these beds be made the base of the Umbral, then the great limestone formation must be considered as a subordinate member of the comparatively restricted Umbral series. For these reasons, I include the beds in question, in the Vespertine series. The Umbral series naturally begins at the top of the "Lewisburg," or "Lower Carboniferous Limestone," at least in the Virginias.

The Vespertine Strata on Greenbrier River.

Commencing at the fault above described, which occurs a little west of Caldwell Station, on the Chesapeake & Ohio R. R., and about six miles west of the White Sulphur, we find on the east side of the deep channel cut by a small stream, highly contorted, and overturned, strata of the Catskill?, while on the western side, and only 100 yards distant, the upper red beds of the Vespertine are seen dipping at an angle of only three or four degrees eastward, toward the contorted strata. These compose the base of the high hill there seen. The middle and upper portions of this hill are composed of the Lower Carboniferous limestone, into which the red strata pass gradually, by several alternations of red marlite and limestone. Passing west, along the railroad, the cuttings show that the red rocks rise gradually with a steepening easterly dip, until within 100 yards of the first exposure of the coal-bearing or middle member of the Vespertine, when they rise suddenly, at an angle of 45°.

These strata are composed almost entirely of deep red crumbling marlites. Some insignificant beds of flaggy, reddish, and gray sandstones, occur in the passage beds near the base of the limestone, and toward the middle of the series. Some of the thin flags at the top of the system show beautiful ripple marks. Toward the base, as we approach the coal-bearing member, the marlites are no longer of uniform red color, but are variegated with green and grayish splotches. The principal portion of the red strata much resembles some of the red shales of the supposed Catskill, which will be described farther on. The entire thickness is by estimate 250 feet.

This red upper member seems, from the measurements of Professor Rogers, to thin out to the north. As remarked above he puts it with the Lewisburg limestone, which is probably the equivalent of the St. Louis and Chester groups, in his Umbral series.

In his measurement of the Umbral in Greenbrier Mountain, near Huntersville in Pocahontas county, he puts fifty feet of red shales under the limestone. This point is thirty miles north of my section.

Still farther north, on the Potomac, near Westernport, Professor Rogers gives no red beds under the limestone, but shows that fifteen feet of red shales and sandstone occur about twenty feet from the base, which is composed of reddish and sandy gray limestone.

In the vicinity of the Greenbrier River, as above mentioned, the coal-bearing portion of the Vespertine rises boldly from beneath the red marlites, and forms cliffs of imposing height near the railroad bridge. These strata, however, do not attain a sufficient height to disclose the white sandstones and conglomerates, which form the lower member of the Vespertine in the two Virginias. Across the river they soon come down with a westerly dip, and disappear under the limestone to appear no more. This broad anticlinal seems to be the last important undulation affecting the strata in a westerly direction, for these maintain apparently a westerly dip nearly to the Ohio River.

In my article on the "Conglomerate series of West Virginia," published in the numbers of this Journal, for April and May, 1876, I have given some account of the geology of the country lying in that direction.

The middle member of the Vespertine as disclosed here, shows at its top, about seventy feet of rather siliceous, bluish gray sandstones, in thin beds, and of very firm texture. Under these occur about forty feet of thinly bedded, gray flags, which show throughout a curious distribution of carbonaceous matter. Fully fifty, pretty persistent, thin strings of carbonaceous material, are distributed over this space, being usually not more than an inch or so thick, but sometimes suddenly swelling out to the thickness of nearly a foot. No underclays exist, and all the material was plainly derived from drifted vegetation. This is also indicated by the frequent mixture of the carbon with the substance of the sandstones.

But while this portion of the field seems to have been under water, a portion of the neighboring area was in a condition to permit the development of a considerable coal bed. I have reliable information that some two and a half miles north of this point, and near the river, a coal bed exists at this horizon. At one time attempts were made to work it, but the coal proved to be too impure, and full of sulphur. It is locally about four feet thick. This is the coal bed mentioned by Professor Rogers, as existing on the river near Lewisburg.

Beneath the above mentioned carbonaceous portion, come 120 feet of firm gray, and brownish sandstones, and then forty feet of very flaggy, gray, soft sandstones and shales, with some layers of fissile black shale, containing indistinct vegetable impressions, mostly leaves of Lepidodendra. The lowest rock seen shows about twenty feet of dark gray, compact, fine grained sandstone, full of specks of pyrites, and containing in nests and pockets of yellow ochre poorly preserved impressions of shells. The entire thickness, here shown, of the middle member, is by estimate about 290 feet.

Professor Rogers shows that farther north, where the Vespertine forms a portion of the mass of the Alleghany Mountains, this member shows pretty much the same features, but that the amount of coal is much smaller, since it appears only in occasional thin strings of very small lateral extent.

Vespertine Strata near Lewis Tunnel.

Twelve miles east of the last mentioned locality we find the Vespertine rocks disposed in a narrow belt along the east side of the Alleghany Mountains. The Chesapeake & Ohio Railroad issues from this mountain, on the east side, in a deep cut made in Chemung strata, which dip about 75° southeast. Passing along the railroad eastward, we enter first the strata intermediate between the Chemung and Vespertine, which are probably Catskill, and after passing through these, see the lowest beds of the Vespertine, coming next in order. The dip flattens down rapidly in going east, until in the Vespertine strata it is not more than 25°.

The Chemung here is much like that of New York. Alternations of flaggy sandstones and shales, weathering olive brown in color, form the principal portion of the mass. Toward the top, rather massive, dull gray, and dingy brown sandstones occur, with some portions containing pebbles as large as a garden pea. Thin layers, crowded with impressions of shells, occur at intervals, being found even in the coarse sandstones. The highest strata showing Chemung fossils, are these coarse sandstones; succeeding them, the rocks show a decided change, and in this portion, the Catskill beds, if they exist at all here, must be found. The following is a section of them, with the thickness estimated in part. (1.) 120 feet of alternations of deep red marlites, and thick-bedded, rather argillaceous, reddish-brown sandstones. The sandstones and marlites are in about equal proportions. (2.) Seventy feet of dark red marlites, interstratified with ochreous sandstones of very argillaceous character, and showing balls and nests of brown hematite, arising from balls of pyrites. The sandstones when fresh are of dull brown color, but in weathering, assume yellowish-brown hues, in spots and patches. (3.) For 150 feet the ground is not well exposed, yet appears to be occupied by strata like the last, with a greater predominance of the sandstone. In (2), the marlites are confined to the lower portion next to (1). These three members, possessing a thickness of 340 feet, in which ferruginous matter abounds, are in all probability of Catskill age, but as they, so far as I know, contain no fossils, the question cannot be answered with certainty. These are succeeded by about 500 feet of flaggy sandstones, with interstratifications of shales, all when fresh dingy yellow, or brownish gray, but weathering to a dull brown color. These strata are of still more problematical age. As however in the eastern exposures, the Vespertine lower member seems to thicken at their expense, I include them with it. The junction of these beds with the lowest undoubted Vespertine strata, is here concealed by slides, as is partially, a considerable portion of their upper member.

Above the highest of these beds we have a decided change in the character of the deposits, and here I place the base of the Vespertine. This rock is a white, pebbly, highly siliceous sandstone, in the lowest portion seen. Its base is not exposed here. The pebbles are mostly small, but some of them attain the dimensions of half an inch. The great mass of the rock, especially the middle and upper portions, is a coarse sandstone of impure white color, becoming somewhat argillaceous at the top. The thickness seen was about sixty feet. This rock, it will be remembered, was not brought up at the place examined on Greenbrier River.

This is one of the most persistent and highly characteristic members of the Vespertine. Though always containing conglomerate bands, and marked by its siliceous character, it shows considerable changes in thickness, and the coarseness of its texture. Along the Greenbrier River the conglomerate portion, when exposed, often shows pebbles an inch in diameter. Professor Rogers mentions an exposure near Huntersville where the pebbles are even two inches in diameter.

Next above the sandstone member at Lewis Tunnel, we find the middle member as on the Greenbrier River, containing gray flags with coal. It is here fully exposed, and is by estimate about 350 feet thick.

The base is composed of forty feet of argillaceous, thick-bedded sandstones of a dull yellowish gray color, succeeded by twenty feet of firm olive colored sandstones. Some one or two thin films of coal occur in the first named, associated with black shale. The second stratum brings us to about the horizon of the lowest rocks seen on Greenbrier River. The succeeding strata here are in the main much like those west of the White Sulphur, being mainly gray flags. About fifty feet above the last mentioned stratum we find a true coal system, showing underclays with rootlets. The following is a section of it, beginning at the base:

1. Bluish-black, sandy shales, 5 feet.
2. Fire clay, 5 inches.
3. Coal, 8 inches.
4. Brown, flaggy sandstones, 3 feet.
5. Slaty coal, 6 inches.
6. Black shale, 12 inches.
7. Gray sandstone, 30 feet.
8. Fire clay, 12 inches.
9. Coal, 1–2 inches.
10. Fire clay, 5 feet.
11. Slaty coal, 5–6 inches.
12. Sandstone, 3 feet.
13. Black sandy slate, 15 ft.

No. 7 contains films and streaks of coal from floated vegetable matter. No. 10 is full of Pinnularia rootlets. No. 13 shows plainly the marks of considerable erosion of the underlying beds. It is charged with carbonaceous matter, and contains films and fragments of coal. Indeed there are evident signs that several of the small coal beds suffered considerably from erosion, before the deposition of the overlying strata. The lower part of No. 13, for some four or five feet, contains large angular fragments of No. 1, mixed with others from the underlying Devonian brown sandstones. Some of the fragments are three or four inches in diameter. With the exception of No. 1, all the black shales of the section seem to be composed of material derived from the red and brown Devonian strata. On losing by weathering the carbon to which they owe their black color, they assume reddish and brown hues.

The coals are really two in number, disposed in an upper and lower double bed, about thirty feet apart, which accords well with their distribution throughout the Vespertine coal field. The material is very impure, slaty and full of sulphur.

Over No. 13 we find about seventy-five feet of firm siliceous, rather coarse, bluish-gray sandstones, containing fragments of the lower coal-bearing rocks, with drifted stems and pieces of coal. Lewis Tunnel is cut in these rocks.

Over this we have twenty feet of gray sandstone of firm texture, graduating into ten feet of firm thin bedded shales, black when fresh, but weathering brown. This last contains the small coal bed at the entrance to Lewis Tunnel, and has afforded all the plant impressions found there. The coal is quite local, and has been found nowhere else so far as I know. This horizon however, in other places, often yields abundant plant impressions.

At the top we have some alternations of dark shales, with olive, and reddish marlites for thirty feet, and finally red marlites. No limestone was seen above the red marlites. The conditions here indicate a quieter deposition of sediment than that which took place near Greenbrier River, for there the firm gray flags are succeeded abruptly by the marlites. The uppermost coal bed here exposed is, at its thickest, about twelve inches, but soon passes into shale.

We find from the above data that in this section the Vespertine strata may be divided into three members.

1. A lower member, characterized by siliceous sandstones and conglomerates. Thickness exposed, sixty feet. With this should probably be counted 500 feet of underlying, more argillaceous flags, giving a total of 560 feet.

2. A middle member, characterized by the predominance of gray sandstones containing coal. Thickness, about 350 feet.

3. An upper member, consisting almost entirely of red marlites, and having a thickness of about 250 feet. This would give the entire group a thickness of 1,160 feet.

It will be seen that, as the base of the lower member is nowhere exposed in this region, sixty feet cannot be taken as its entire thickness. I am of the opinion that it is considerably greater. Professor Rogers, in his descriptions of the Vespertine, nowhere gives any descriptive section of the strata, so that we are left in doubt as to what stratum he assumes as its base. It is plain that he does not include the red overlying strata in it; this makes it difficult to use his measurements, as a basis for comparison. He gives the thickness on the Potomac near Westernport, as only 200 feet, while near Lewisburg he says it has increased to 800 feet. This seems in any event, to establish the fact of a considerable thickening to the south.

[To be continued.]

ART. VII.—*On the production of Transparent Metallic Films by the Electrical Discharge in exhausted tubes; by* ARTHUR W. WRIGHT, Professor of Molecular Physics and Chemistry, Yale College.

THE spectra of gases contained in vacuum-tubes, which have been prepared by the use of the mercury pump, usually exhibit lines caused by the presence of the vapor of this metal. In some cases this is no disadvantage, since they serve as convenient reference points in fixing the position of the other lines or bands observed. As the mercury vapor is naturally an excellent conductor of electricity, however, there is often reason to suspect that its presence may affect the character of the discharge somewhat, and its removal becomes desirable. In some recent experiments by the writer this end was obtained by placing in each tube a few pieces of clean gold foil loosely rolled into small pellets. As this metal is readily amalgamated it will, after a time, take up the mercury vapor, causing the disappearance of its characteristic lines from the spectrum. A still better method is to wrap a small piece of the foil about the end of the electrode, or to attach to it a short gold wire. The gold will be volatilized and deposited upon the walls of the tube in a very thin layer, thus exposing a much larger surface to the action of the mercury vapor, in the manner described below.

In some of these experiments the tube under examination was so placed that the gold lay at the bottom of the upper portion, at the point where the capillary part is attached. In this position it was exposed to the action of the more intense discharge through the narrow part, and after a time it was found that a lustrous and coherent film was deposited upon the glass, the gold having evidently been volatilized by the electricity and condensed upon the walls of the tube. In order to study more conveniently the conditions under which the best effects might be produced, a loose roll of the foil was placed in the middle of a tube about five millimeters in caliber, having a branch near one end for the purpose of withdrawing the air, and with platinum electrodes inserted into the ends. This was exhausted until a discharge from an induction coil passed readily, when it was found that the gold was speedily deposited upon the tube as before, and by shaking the foil along, a considerable area was covered with it in a short time. It appeared, even under the microscope, as a perfectly continuous film, forming a brilliant mirror, and showing the characteristic green color by transmitted light very beautifully. When the tube was afterwards rather strongly heated the gold lost its mirror-like surface in the thinner parts, assuming a frosted appearance, and the light passed through it had a fine ruby color, conforming in this to what was observed by Faraday in his experiments on the relation of metals to light.* A singularity in the result was the fact that the volatilization occurred only at that end of the foil which was made a negative pole. This was observed to be the case in all the subsequent experiments, except that in one or two instances where a powerful discharge had been maintained for a considerable time a very slight deposit was observed at the positive end also.

As the matter appeared to be of interest with respect to its furnishing a new method of producing transparent metallic films, the investigation was extended to a considerable number of metals. Various forms of tubes were employed in successive trials, but the method found most advantageous was the following: clean tubes of white glass, about fifteen centimeters in length, and with a caliber of from four to six millimeters, were provided in the middle with a small branch tube for attachment to the pump. In the ends were placed the electrodes formed of the metals to be examined. These were generally in the form of thin wires from one-fourth to one-half a millimeter in thickness. About one centimeter of this was enclosed in a thin glass tube about three centimeters long, drawn out of the same piece as the main tube, and made so fine at the end as just to receive the wire. A platinum wire was placed in the other end, so as to touch the first wire, and sealed in. This was then carefully sealed into the end of the main tube, the electrode being in its axis, and the platinum wire projecting. It was necessary to cover the latter thus in the interior to prevent its giving a deposit upon the tube with the metal under examination. The tube was now exhausted to a tension of one or two millimeters, or so far that, when the discharge from the induction coil was passed through it, the glow surrounding the negative pole filled the tube along the whole extent of the electrode. After the coil had been put in operation for a few minutes a deposit was formed upon the glass, appearing at first as a mere darkening or discoloration, which, gradually becoming deeper, finally began to show metallic luster, while still suffering the light to pass freely. In almost all cases it covered the whole area of the glass opposite the electrode, but did not extend much beyond it. After the film was sufficiently developed the small branch was closed with a gas flame, the tube drawn off, and sealed.

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* Experimental Researches in Chemistry and Physics.

For metals readily oxidized it was necessary to fill the tubes with some gas which would not act upon the deposit formed, as otherwise it was impossible to obtain good results. In these cases the air was first thoroughly removed, the tube filled with pure dry hydrogen, and then exhausted. In a few cases the tubes were refilled with hydrogen several times to ensure the complete removal of the oxygen. The perfection of the film was found to depend also in some measure upon the steadiness of the electrical action, and the proper regulation of the power of the current used. When the Holtz machine was employed as a source of electricity no effect was obtained without condensers, and with them the discharge, at least with the tension of gas used, did not occur in such a manner as to yield good results. The trifling deposit obtained in this way was opposite the positive electrode. Possibly by exhausting the tubes so as to reach a much lower tension the electro-machine might be made available, but the induction coil is both efficient and convenient.

With a gold wire one-third of a millimeter in diameter and four centimeters long, an exquisitely beautiful deposit was formed over a space a little longer than the wire. The first noticeable effect was a slight discoloration of the tube by the deposited metal, while it was still too thin to show the metallic luster by reflected light. The tint was pinkish, inclining to violet, resembling that at the more refrangible end of the spectrum. As the film increased, the tint passed through blue, bluish-green, and finally, when of sufficient thickness, it appeared a clear, brilliant green, slightly inclining to bluish-green. By reflected light the film has a splendid luster, and the full golden color. It thins out gradually at the extremities, and becomes imperceptible at a point five or six millimeters from the end of the wire, with the same gradation of tints as was observed in its formation. The metallic reflection fades out in a similar manner, but ceases before the coloration.

With silver wire of about the same dimensions, the coating upon the tube was scarcely less beautiful and perfect. The full luster was developed gradually, and the light transmitted by the completed film is a pure, deep blue. Copper gives a fine lustrous mirror, appearing dull green by transmitted light. It is volatilized with more difficulty than the preceding metals. Bismuth on the other hand is obtained in a thin film with extreme ease, a battery of three small Grove cells with a coil giving a half inch spark producing the desired result in two or three minutes. The film is very transparent, and has a color such as would be produced by mixing a clear blue with a pure gray or neutral tint. The metallic layer is remarkably uniform, and of great beauty, possessing a brilliant luster by reflected light.

Platinum is volatilized with comparative ease, especially in a narrow tube. Its deposition on the glass in this way is a familiar occurrence, as few of the common vacuum-tubes which have been subjected to the action of the induction coil for a long time fail to show the effect. In a small tube the layer is very bright, and is easily made thick enough to be quite opaque. When sufficiently thin, it transmits light of a gray color, with a slight bluish tinge. Palladium also is deposited in a thin layer without difficulty, and appears of a smoky brown color by transmitted light. Lead forms a very even film, with the characteristic color of the metal, though it has but a comparatively feeble luster. It has a high degree of transparency, appearing of a smoky-brown color, inclining to an olive tint when very thin. Thorough exclusion of the oxygen and vapor of water is necessary to the successful formation and preservation of the film, as when exposed to the air or moisture it is destroyed by oxidation in a very few minutes.

Zinc and cadmium yielded brilliant mirrors, with a white, silvery luster, and appearing deep grayish-blue by transmitted light, with a barely noticeable inclination to purple. It is less deep in tint than the light passed through silver, but deeper than that from bismuth. There was no perceptible difference between the two metals, unless it were a slightly greater intensity of the coloration in the case of the zinc.

Aluminum was volatilized with considerable difficulty, requiring five or six cells and a powerful coil. It formed a mirror-like film, which by transmitted light had a brownish color, but the result was not entirely satisfactory. Magnesium yielded even less readily, and showed no effect at all when tried with the means which had given good results in the other cases. It was necessary to reduce the electrode to a very fine wire, and this was enclosed in a tube of only 3·5 millimeters caliber. The larger coil was used, and the power of the battery gradually increased to six Grove cells. Not the slightest effect was produced when a smaller number was employed, but after the application of this power for a few minutes, the electrode was suddenly surrounded by a burst of green light, and the deposit was formed almost instantly upon the glass. It had a brilliant luster, and when the light was seen through it, a grayish-blue color similar to that of zinc or cadmium, but less clear.

Tin did not give very satisfactory results, as when the electrode was made small enough for the purpose it was difficult to avoid fusing it. The film when obtained was not as fine as those produced with the other metals mentioned, but had in some parts a silvery metallic luster, and was sufficient to show that when seen by transmitted light the metal appears of a brownish gray or sepia tint.

Interesting results were obtained with iron, which gave a very beautiful and perfect film, having a brilliant luster, and a high degree of transparency. The light transmitted by it is very nearly of a pure neutral tint, though with a faint tinge of brownish. The electrode was a wire 0·3 millimeter in diameter. This was carefully cleaned, and the tube filled with dry hydrogen three times before the final exhaustion. Without this precaution it is impossible to obtain reliable results, as the metal is partially oxidized, and the film not only stained, but its color by transmitted light changed to brown, or even to deep orange-yellow. This was the color exhibited by the film obtained in the first trial, in which the tube was filled with air. Externally it exhibited a vivid iridescence, in various colors, but at the extremities of the deposit the metal had its proper luster. Subsequent trials in which the tube was once filled with hydrogen gave better results, but the yellow tint and the iridescence did not disappear until the thorough removal of the oxygen and moisture, as described.

For those metals which are not readily obtained in the form of thin wires, a modification of the process was employed, as follows: a tube open upon one side was made by softening the end of a glass tube in a gas flame and drawing out one edge with another piece of glass. A trough was thus formed, at first shallow but growing deeper and deeper as the whole edge began to be drawn upon, and by properly adjusting the heat applied, it could be made as fine as desired. A tube of this kind from half a millimeter to a millimeter in diameter with a platinum wire inserted in the closed end, and with the open end evenly and firmly packed with filings or powder of the substance to be examined formed the electrode, which was used in the ordinary way.

Nickel and cobalt were experimented upon by this method, and films obtained, but as the removal of the oxygen was not sufficiently complete they were less perfect than those produced from the other metals, though sufficient to show that the color by transmitted light is gray or brownish gray. Tellurium employed in the same way afforded a very brilliant layer, which gave to the light seen through it a dull purple color.

At the suggestion of Prof. Dana an experiment was made with magnetic oxide of iron, native magnetite in powder being employed with one of the small troughs. It was volatilized with difficulty, but apparently without decomposition, and formed a somewhat lustrous film, appearing gray-brown by transmitted light. The result is of interest with reference to the occurrence of thin, somewhat transparent layers of this substance in certain micas, where it has the same color as that observed in this experiment.

In Faraday's experiments deposits of several different metals upon plates of glass or other materials were obtained by passing the spark from a Leyden battery between the points of wires near the plates in an atmosphere of hydrogen. Films so obtained are more or less irregular, and he describes them as apparently not entirely continuous. Those formed by the method here described, however, are generally very uniform and coherent, and even under the microscope appear to be perfectly continuous. For a study of the optical properties of the metals they can be formed upon narrow slips of plane glass introduced into the tubes by the side of the electrode. Simple examination of the tubes with a Nicol's prism shows that these films, at least in the case of gold, silver, iron, zinc and cadmium, which have been tried by the writer, polarize the light transmitted by them powerfully, and the degree of polarization appears to increase with the incident angle as far as observation can be conveniently carried, which implies a very high refractive index. It might be expected that the light should be elliptically polarized, but this point was not determined, and the optical properties of the films remain for further study.

With respect to the relative energy of electrical action necessary to volatilize the different metals the observations were hardly precise enough to warrant the statement of a definite law. Bismuth was volatilized most readily of all, gold and silver with but slightly less facility. Platinum, palladium, lead, tin, zinc and cadmium yield less readily, while copper, iron, nickel and cobalt require a rather intense discharge and are volatilized with some difficulty. Aluminum requires an energetic electrical action exerted for a long time, and the electrode must be a quite fine wire. Magnesium is acted upon still less readily, and is by far the most difficult, of all the metals tried, to be obtained in the state of a thin layer. Success was attained by the use of an energetic battery of five or six Grove cells, with a coil capable of giving two-inch sparks, the electrode being a wire cut from a thin ribbon of the metal and not more than one-fifth of a millimeter in thickness. Even then no effect was produced till this was enclosed in a very narrow tube by which the electrical action was concentrated. The electrode itself appeared bright green, showing that the discharge did act upon the metal, forming a thin envelope of vapor about it, which did not reach the glass however until the power of the current was increased and the size of the tube considerably diminished. It will be seen that the heavy metals, that is, those with high atomic weights, are most readily volatilized, while those with smaller atomic weights oppose great resistance to the electrical action, and those with medium weights occupy an intermediate position; but the fusibility, tenacity, and electrical conductivity also appear to exert some influence as to the place of the different metals in the list.

It may be observed also that where it is desirable to avoid discoloration of vacuum-tubes by the metallic deposit, this can be effected by making the electrode within the tube of aluminum or magnesium, the interior portion of the platinum wire which passes through the glass being itself covered with a small glass tube. Of the two metals magnesium is the best, as a wire half a millimeter in diameter would not be at all affected by discharges of the intensity ordinarily used with vacuum-tubes, nor would it be so easily fused or rendered red hot as a wire of platinum. Of course these metals could only be used with gases which would have no chemical action upon them.

Yale College, December 13, 1876.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the so-called Crystallized Boron.*—HAMPE has prepared and submitted to careful examination both of the forms of the so-called crystallized boron, the black and the yellow, and finds that neither is pure boron, both being compounds of this substance. For the preparation of the black variety, 200 to 400 grams of fused coarsely pulverized boric acid was placed in an English clay crucible, a piece of aluminum weighing 100 to 200 grams was laid upon it and covered with boric acid, and then the cover of the crucible was luted on with clay. The whole was enclosed in a Hessian crucible, the space between the two being filled with quartz sand. The secret of the production of the black crystals consists in the absence of carbon in the crucible. The fusion was effected in a melting furnace, the fuel used being coke, and the time of heating three hours. By closing the draft almost completely, the cooling took place very slowly, requiring from 12 to 18 hours; the crystals being increased in size proportionally. On breaking the inner crucible when cold, the upper layer of the fused mass was glassy and consisted of aluminum borate. Within this was a thin dense very hard layer of pure alumina, which surrounded the regulus. The free surface of the metal as well as the cavities in it were covered with magnificent black crystals, which were obtained on solution of the aluminum, accompanied by red hexagonal plates of the aluminum boride of Wöhler and chocolate-brown crystals of silicon. The yield was small, only 2·5 to 3 grams being obtained from 100 grams aluminum, one gram of which proved completely pure. Various other methods of preparation were tried; but the yield was less in every case. The crystals are monoclinic prisms, have a brilliant metallic luster,

are black in thick but dark red in thin layers, become blued like steel when heated in the air though not combustible when heated in a stream of oxygen. Their hardness is between 9 and 10, their density 2·5345. Concentrated hot nitric acid dissolves them slowly, fused potash and lead chromate rapidly. On analysis they yielded 17·30 per cent of aluminum and 82·70 per cent of boron, corresponding to the formula AlB_{12}. The yellow quadratic crystals were obtained by effecting the fusion in carbon crucibles; one melting, which was on a large scale, yielding 5·528 grams pure crystals, on some of which the octahedral edges were 4 mm. long. They are honey-yellow in color, very brittle, harder than corundum and nearly as hard as the diamond, and have a density of 2·615. On analysis they gave as a mean: Aluminum 13·15, iron 0·24, copper 0·04, carbon 3·76, boron (by difference) 82·81; corresponding to the formula $C_2Al_3B_{48}$. All attempts to prepare pure boron crystallized were fruitless. The author is now examining the so-called amorphous boron in this direction.—*Liebig's Annalen*, clxxxiii, 75, Oct., 1876. G. F. B.

2. *On the Constitution of the Phosphates.*—BERTHELOT and LOUGUININE have made a thermic research on phosphoric acid with a view to determine its basicity. They studied the heat-changes characterizing the union of this acid with two widely different bases, ammonia and baryta, and those produced by water and by various acids of different energy upon the three classes of phosphates. To these, they added alkalimetrical evidence. The conclusion which they reach is that the three equivalents of base, successively united to phosphoric acid, are thus united with very different values; the first equivalent being comparable to that of the nitrates or alkali chlorides, the second to that of the carbonates and borates, and the third to that of the alkali alcoholates. When for example, phosphoric acid and soda unite, the union of the first equivalent of the base evolves 14·7 calories, the second 11·6 calories and the third 7·3 calories; while in the case of a true tribasic acid like citric, the quantity of heat is constant for each equivalent, being in this case 12·7 calories. In the case of ammonia, no heat at all is evolved on adding the third equivalent, and hence no triammonium phosphate exists. In view of the results obtained, the authors say that phosphoric acid cannot be a tribasic acid, at least in the same sense as citric acid, the third equivalent of base being separated even by dilution; nor can it be a dibasic acid like sulphuric, oxalic, or tartaric acid, since the second equivalent of base is not neutralized by the acid and is entirely separable by hydrochloric and nitric acids and even partially by acetic. Hence they regard it as an example in inorganic chemistry of what in organic chemistry are called monobasic acids with a mixed function.—*Ann. Chim. Phys.*, V, ix, 33, Sept., 1876. G. F. B.

3. *On the Critical Point of Liquid Carbon Dioxide.*—HARTLEY has made further examinations of the liquid enclosures in minerals and has determined with care the critical point of temperature

for a large number of those composed of liquid carbon dioxide. Curiously enough this point was found to vary considerably: In topaz, in three specimens, the critical point was 28·5°, 26·5° to 28°, and 27·5° to 27·6° C.; in two specimens of tourmaline, from America, it was 27·27° and 26·9°; in five quartz specimens, it was 30·95°, 30·95°, 32·5°, 33·7° and 29°; in a beryl from Lurat, it was 30·92°; in three oriental sapphires, 30·5° to 31°, 25·5° to 26°, and 29·5°. The author explains this lowering of the critical point by the fact observed by Andrews that this effect is produced by the presence of an incondensable gas, perhaps nitrogen. The raising of the critical point appears to him to be due to hydrochloric acid gas. The facts observed seem to the author to have a bearing on the question of the formation of some of these minerals, and he suggests that corundum may have been formed by the action of aluminum chloride or fluoride upon calcium carbonate, producing alumina and carbon dioxide; the latter being condensed, would form cavities in the alumina crystals and would liquefy on cooling. If the reaction were dry, the cavity would contain only the dioxide; but if moisture were present, it would contain water also. With reference to the diamond, he suggests that it may have been formed by the action of reducing agents upon very highly compressed carbon dioxide at temperatures above its critical point. —*J. Chem. Soc.*, xxx, 237, Sept., 1876. G. F. B.

4. *On the Spectra of Indium.*—CLAYDEN and HEYCOCK while observing the spark spectra of the metals, in the Cavendish Laboratory, Cambridge, noticed that instead of the three lines which are ordinarily supposed to constitute the spectrum of indium, the spark spectrum really contained sixteen. The wave-lengths of the three lines are given by Thalén as 4532, 4509 and 4101 tenth-meters. The second and third only of these lines are visible in the spark-spectrum. The wave-lengths of the sixteen lines the authors give as follows: 6906, 6193, 6114, 6095, 5922, 5905, 5862, 5820, 5722, 5644, 5250, 4680, 4656, 4638, 4510, and 4101 tenth-meters. The first of these lines is remarkable for its low refrangibility, only potassium, strontium and antimony giving lower ones. The wave-lengths were not measured directly apparently, but obtained by interpolation from the scale of the four-prism spectroscope with which the measurements were made.—*Phil. Mag.*, V, ii, 387, Nov., 1876. G. F. B.

5. *On the Preparation of Hydroquinone.*—WESELSKY and SCHULER have discovered a new and comparatively simple method of preparing the diatomic phenol of the ortho or 1 : 2 series, hydroquinone. If nitrous acid vapors be conducted into a cooled etherial solution of phenol, the mass is filled in a short time with crystals of diazophenol nitrate. This salt dissolved in dilute sulphuric acid (one of acid and two of water) mixed with alcohol and ether added, becomes sulphate which by precipitating with barium chloride can be easily be converted into chloride. These salts are identical with those prepared by Schmitt from the non-volatile mononitrophenol of fusing point 110°. If now an

aqueous solution of one of the above salts, preferably the sulphate, containing 10 to 15 per cent of concentrated sulphuric acid, be boiled till its color changes to a dark red, and, afterward be extracted with ether, the ether leaves on evaporation crystalline masses which on sublimation give colorless needles, which dissolved with water and treated with ferric chloride, yielded magnificent green needles having a metallic luster. This substance is hydroquinone and the yield is 46·2 per cent, the theoretical being 50.—*Ber. Berl. Chem. Ges.*, ix, 1159, Sept., 1876.

G. F. B.

6. *On Gelsemium sempervirens.*—SONNENSCHEIN has examined the root of the wild jasmine and has isolated its alkaloid, gelsemine, to which he gives the formula $C_{11}H_{19}NO_2$. The substance called by Wormley gelseminic acid, he finds to be esculin.—*Ber. Berl. Chem. Ges.*, ix, 1182, Sept, 1876. G. F. B.

7. *Kurze allgemeine Einleitung zu den aromatischen Nitro-verbindungen* von PETER TOWNSEND AUSTEN. Pamphlet, 43 pages. Leipzig: Winter, 1876.—This little work possesses a peculiar interest, as it is the attempt of an American to produce a comprehensive treatise in a foreign language and country. The manner in which Dr. Austen has treated this class of organic compounds differs greatly from the general style of monographs, and is certainly practical and original. The work is intended to afford all necessary data to those working on researches involving the nitro-compounds. The arrangement is such that the facts sought for can readily be found. The style of the book is clear and remarkably concise.

There is no doubt but that similar treatises on various other groups of organic compounds, such as the hydroxyl, amids, and many others, would enormously facilitate the labors of chemists engaged on original research.

The book is dedicated to Prof. A. W. Hofmann, of Berlin.

8. *Mariotte's Law.*—Prof. MENDELÉEFF, at the Warsaw meeting of Russian naturalists, described the results of researches he has pursued during 1875 and 1876, for the verification of Mariotte's law. His former researches had proved that the decrease of volume of the permanent gases proceeds at a slower rate than the increase of pressure exerted on them, if the pressure is less or much greater than the mean pressure of the atmosphere. The experiments of Regnault, made with air, nitrogen, etc., at pressures higher than that of the atmosphere proved, however, directly the contrary, and a series of measurements undertaken some years ago by Prof. Mendeléeff to verify those of Regnault, gave the same results. Suspecting that there might be some cause of error affecting in the same way both series of experiments, Prof. Mendeléeff and Mr. Bogussky constructed special apparatus eliminating all possible causes of errors and allowing the most perfect accuracy of measurements. With these they made a new series of researches, at pressures varying from 700 to 2,200 millimeters. These researches confirmed again the conclusions of Regnault,

showing only numerical differences in the values obtained, and proving, for instance, for the air, that its deviations from Mariotte's law are even less than appeared before. But the most important results of the researches is that the divergences from Mariotte's law shown by the air being negative at pressure above the mean atmosphere, as was observed by Regnault, proved to be positive (decrease of volume slower than the increase of pressure) at pressures below it. We must then conclude that the air experiences a change of compressibility at a certain pressure above the mean of that of the atmosphere; and this conclusion is supported by the circumstance that such a change was noticed also in the carbonic and sulphurous acid gases, but at pressures far lower than is the case for air. Only for hydrogen the divergence is of the positive kind at all pressures. Altogether we must conclude that the deviations from Mariotte's law are far more complicated than has been suspected.—*Nature*, xv, 70. E. C. P.

9. *Physical Properties of Gallium.*—M. LECOQ DE BOISBAUDRAN has recently prepared more than half a gram of pure gallium. In the liquid state this metal is of a beautiful silvery whiteness; but in crystallizing it assumes a very pronounced bluish tinge, and its luster notably diminishes. Isolated crystals may be obtained which are based octahedra. The melting point was found to be 30°·15, which was unaltered after remaining for two hours in boiling water. It was therefore certainly free from potassium. It was next kept for half an hour in nitric acid diluted with its volume of water. The loss amounted to only a fraction of a milligram, and the point of fusion remained unaltered. The calculation of M. Mendeléeff for a hypothetic substance which seems to correspond to gallium, at least in several of its properties, conducted to the number 5·9. The first measurement with 6 centigrams gave a density of 4·7 at 15°. Later observations gave the higher results of 5·5 to 6·2. Finally, a measurement with 58 centigrams gave, in two experiments, 5·90 and 5·97. The same gallium was afterwards kept during half an hour between 60° and 70° in nitric acid diluted with its volume of water, washed, pretty strongly, heated, and, finally, solidified in dry air. Its density at 24°·45 was then 5·956.—*Comptes Rendus*, lxxxiii, 611, *Phil. Mag.*, ii, 398. E. C. P.

10. *Plasticity of Ice.*—Prof. BIANCONI, of Bologna, in 1871, published some experiments on the bending and torsion of bars and planks of ice (*Mem. Acad. of Bologna*, 3d ser., vol. i.) These show that ice may undergo slow changes of form without any crushing or regelation, and that notwithstanding its brittleness it possesses a slight degree of plasticity. Now Prof. Bianconi gives the results of further experiments on ice, much like those of Heim, or, yet more, those of Mr. Tresca on the puncheoning of metals. Granite pebbles and iron plates are slowly pressed into ice at the same temperatures, and not only do they penetrate into it as they would penetrate into a fluid or semi-fluid, but also the particles of ice are laterally repulsed from beneath the intruding body, and

form around it a rising fringe. Moreover, when a flat piece of iron is pressed into the ice, the fringe rising around it expands laterally upon the borders of the piece, and tends thus, as in fluids, to fill up the cavity made by the body driven in. These experiments tend thus greatly to illustrate the plasticity of ice; but it would be very desirable that Mr. Bianconi if he continues his researches, should accompany them by some measurements (as has already been done by Mr. Heim), in order to obtain numerical values of the plasticity of ice under various circumstances.—*Nature*, xv, 69; *Jour. de Phys.*, v, 317. E. C. P.

11. *Velocity of Electricity.*—Dr. SABINE has devised a method of measuring the contour of electric waves passing through telegraph lines. It is probable that in this sense alone electricity may be said to have a velocity. The early experiments on the time elapsing between starting electricity into one end of a conductor and receiving it at the other end, gave totally contradictory results. This interval would depend on the electromotive force employed, the resistance and capacity of the conductor, and the sensitiveness of the receiving instrument. It would therefore by no means be proportionate to the length. By the following method the electrical condition of any point of the line may be examined quantitatively at intervals of ·001 of a second or less after starting the electric impulse. It thus becomes possible to measure the form and speed of a wave. Suppose one end *A* of a conductor *A B* is placed to earth, and that the other *B* is connected with one pole of a battery whose second pole is put to earth. Then any point of the conductor as *C* will assume a potential which will be proportional to the resistance of *A C*. This potential may be measured by connecting *C* for an instant with a condenser or accumulator, and then discharging the latter through a delicate galvanometer. When the circuit is first closed a minute interval of time is required before *C* will attain its full potential measurements made of the relation of these quantities show the form of the electric wave passing the point *C*. The only mechanical difficulty is to construct a chronograph which will allow *C* to be connected with the condenser, a small but accurately determined time after *A* is connected with the battery. A heavy wheel of brass is set in motion by a steel spring so that it shall revolve exactly twice a second. The interval through which the spring acts being always the same, a nearly constant velocity is always imparted. The disc is divided into 500 equal parts. A movable index serves to regulate the angle through which the disk turns between the two connections to be recorded. The time of revolution of the disk was first determined by noting the figures read in succession under the film of a small telescope, when the disk was illuminated by half-second flashes of an induction coil. The force of the spring and the position of the trigger releasing it were adjusted until the right velocity was obtained. Recently a condenser was discharged through a known resistance for some interval indicated by the disk, and the time calculated

according to the leakage formula, from the initial and final readings of the galvanometer. If the two do not agree, the spring is altered until they do; but its action is found to be very constant and not to need alteration, except after taking the apparatus to pieces for alteration. Several series of experiments are given, and the results show the delicacy and accuracy of the method.—*Phil. Mag.*, ii, p. 321. E. C. P.

12. *Chemistry and Physics in America. Address before the American Chemical Society at its session on the* 16*th of last November, by Prof.* JOHN W. DRAPER, *its President.*—The following is the latter half of the able address of Prof. Draper, the whole of which would here be cited if space allowed. "In our own special science, chemistry, all that has been done has only served to extend the boundary of what remains. The thousands of analyses that have been made have brought us into a wilderness of results. We have not been able to rise to a point of view sufficiently high to discover what is the true place of those results in nature. We try to represent on the pages of our books and on blackboards formulas of the constitution of things, conscious all the time that these are at the best only convenient fictions, which must necessarily change as we gain a more perfect insight into that grandest of all problems, the distribution of Force in Space, and the variations to which it is liable. The geometry of chemistry is that of three dimensions, not of two. We have to consider the relation of points not situated on one plane, and hence it is necessary to employ three axes of reference; nay, even more, we cannot avoid the conception of the mathematical method of quaternions. Our inadequate information respecting the real grouping of atoms is followed as a necessary consequence by imperfection in our methods of nomenclature, the confusion in this respect becoming, as we all too well know, every day worse and worse.

And now while we have accomplished only a most imperfect examination of objects that we find on the earth, see how, on a sudden, through the vista that has been opened by the spectroscope, what a prospect lies beyond us in the heavens! I often look at the bright yellow ray emitted from the chromosphere of the sun, by that unknown element, Helium, as the astronomers have ventured to call it. It seems trembling with excitement to tell its story, and how many unseen companions it has. And if this be the case with the sun, what shall we say of the magnificent hosts of the stars? May not every one of them have special elements of its own? Is not each a chemical laboratory in itself? Look at the clusters in the sword-handle of Perseus; in Cassiopeia, a universe of stars on a ground of star dust; in Hercules, of which as astronomers say, no one can look at for the first time through a great telescope without a shout of wonder—the most superb spectacle that the eye of man can witness! Look at the double stars of which so many are now known, emitting their contrasting rays, garnet, or ruby, or emerald, or sapphire. Each is in accordance with its own special physical conditions, though all are under the same universal ordinance.

Now here a fact of surpassing importance presses itself on our attention. The movements taking place in those distant bodies are taking place under the same laws that prevail here on earth, and in our solar system. The law of gravitation, as developed by Newton, bears sway in all those distant worlds. In them bodies attract each other with forces directly as their masses and inversely as the squares of their distances. There the laws of the emission, absorption, and transmission of light are the same as they are with us. There ignited hydrogen gives forth its three rays, the same rays that it gives forth to us. In the uttermost parts of the universe the law of definite combination, the numerical law, and the multiple law, stand good. Sodium absorbs its two waves of definite refrangibility, and iron gives in the spectra its more than a hundred lines, more than a hundred silent but convincing witnesses of the uniformity of the constitution of the universe. There the number of vibrations that constitute a ray of definite refrangibility is the same we have found it to be here. In the enormous heat of those central suns the dissociation of molecules may be of a higher order than we can reach artificially, but the law under which it takes place is a continuation of the law here. There, though the weight of a given mass of matter is different from what it is with us, it is nevertheless determined by the law that determines here—the law of gravitation. There energy is indestructible, and is measured as it is measured among us, by work. Then is there any boundary that we can assign to natural law—is it not omnipresent, universal?

Perhaps there is no exaggeration in the assertion—for there seems abundant proof of its truth—that the light by which we see some of those distant orbs has crossed through such a prodigious space that millions of years have transpired during the journey. Then the phenomena it brings to us are those that were engendered in the beginning of the vast time so passed. Whatever there is that is in harmony with facts now happening here, is to us an unimpeachable evidence that the laws which were governing in those old ages have undergone no depreciation, but are active as ever until now. Then shall I exaggerate if I say that these laws are eternal in duration?

Infinite in influence, eternal in duration, what a magnificent spectacle? In the resistless energy of the motions of the universe is there not omnipotence? The Omnipotent, the Infinite, the Eternal, to what do these attributes belong? Shall a man who stands forth to vindicate the majesty of such laws be blamable in your sight? Rather shall you not with him be overwhelmed with a conception so stupendous? And yet let us not forget that these eternal laws of nature are only the passing thoughts of God.

But grand as this is, there is something still grander. There is another temple into which we have to pass, not that of the visible but that of the invisible. We must persist in the invasion we have made, in the revolution we have brought about in Physiology. We have to determine the laws which preside in the nervous system of man, and discover the nature of the principle that animates it. Is there not something profoundly impressive in this, that the human mind can look from without upon itself, as one looks at his phantom image in a mirror, and discern its own lineaments and admire its own movements. My own thoughts have of late years been forcibly drawn to this, from a recognition that the interpretation by the mind of impressions from without takes place under mathematical laws, as for instance, that when external ethereal vibrations create in the mind a certain idea, that same idea will arise when the vibrations are doubled, or tripled, or quadrupled in frequency; but other ideas will be engendered by vibrations of an intermediate rate. Yet what these ideas will be may be predicted. It is true that this is only an optical case, but it extends the view that has been offered to us by a study of the structure of the ear. In the labyrinthine compartment of that organ the ultimate fibers of the auditory nerve are laid on the winding plane of the spiral lamina, in ever-decreasing lengths, each capable of trembling to the sound which is in unison with it —a mechanical action truly, answering to the sympathetic vibration with which the strings of a piano will respond to the corresponding notes of a flute—and these are translated by the mind into all the utterances of articulate speech, all the harmonies of music—speech that engenders new ideas within us, strains which, though they may die away in the air, live forever in the memory. The exquisite delight we experience in listening to the works of our great composers arises thus in mechanical movements, which are the issue of mathematical combinations. The unseen world is under the influence of number!

But what is number except there be one who numbers? When Pompey, in his Syrian war, broke into the holy of holies at Jerusalem, he expressed, as Tacitus tells us, his astonishment that there was no image of a Divinity within; the shrine was silent and empty. And so, though after death we may anatomize and explore the inmost recesses of the brain, the vailed Genius that once presided there has eluded us, and has not left so much as a phantom trace, a shadow of himself.

The experiments of Galvani and Volta have not yet reached their conclusion; those of Faraday and Du Bois Reymond have only yielded a preliminary suggestion as to the nervous force. Excepting the great sympathetic nerve, the nervous fibers themselves are, as is well-known, of two classes—those that gather the impressions of external things and convey them to the nerve-centers, and those that transmit the dictates of the will from within outwardly. The capabilities of one of the former—the apparatus for sight—have been greatly improved by various optical contrivances, such as microscopes and telescopes, an earnest of what may hereafter be done as respects the four other special organs of sense; and as concerns the second class, the result of mental operations, the resolves of the will, may be transmitted with greater velocity than even in the living system itself, and that across vast terrestrial distances, or even beneath the sea. Telegraphic wires are, strictly speaking, continuations of the centrifugal nerves, and we are not without reason for believing that it is the same influence which is active in both cases.

In a scientific point of view, such improvements in the capabilities of the organs for receiving external impressions, such extensions to the distances to which the results of intellectual acts and the dictates of the will may be conveyed, constitute a true development, an evolution, none the less real though it may be of an artificial kind. If we reflect carefully on these things, bearing in mind what is now known of the course of development in the animal series, we shall not fail to remark what a singular interest gathers round these artificial developments—artificial they can scarcely be called, since they themselves have arisen interiorly. They are the result of intellectual acts. Man has been developing himself. He, so far as the earth is concerned, is becoming omnipresent. The electrical nerves of society are spread to a plexus all over Europe and America; their commissural strands run under the Atlantic and the Pacific.

In many of the addresses that have been made during the past summer, on the Centennial occasion, the shortcomings of the United States in extending the boundaries of scientific knowledge, especially in the physical and chemical departments, have been set forth. "We must acknowledge with shame our inferiority to other people," says one. "We have done nothing," says another. Well, if all this be true we ought perhaps to look to the condition of our colleges for an explanation. But we must not forget that many of these humiliating accusations are made by persons who are not of authority in the matter; who, because they are ignorant of what has been done, think that nothing has been done. They mistake what is merely a blank in their own information for a blank in reality. In their alacrity to depreciate the merit of their own country, a most unpatriotic alacrity, they would have us confess that for the last century we have been living on the reputation of Franklin and his thunder-rod.

Perhaps, then, we may without vanity recall some facts that may relieve us in a measure from the weight of this heavy accusation. We have sent out expeditions of exploration both to the Arctic and Antarctic seas. We have submitted our own coast to a hydrographic and geodesic survey, not excelled in exactness and extent by any similar works elsewhere. In the accomplishment of this we have been compelled to solve many physical problems of the greatest delicacy and highest importance, and we have done it successfully. The measuring rods with which the three great base lines of Maine, Long Island, Georgia, were determined, and their beautiful mechanical appliances, have exacted the publicly expressed admiration of some of the greatest European philosophers, and the conduct of that survey their unstinted applause. We have instituted geological surveys of many of our States and much of our Territories, and have been rewarded not merely by manifold local benefits, but also by the higher honor of extending very greatly the boundaries of that noble science. At an enormous annual cost we have maintained a meteorological signal system, which I think is not equaled and certainly is not surpassed in the world. Should it be said that selfish interests have been mixed up with some of these undertakings, we may demand whether there was any selfishness in the survey of the Dead Sea? Was there any selfishness in that mission that a citizen of New York sent to equatorial Africa for the finding and relief of Livingstone, any in the astronomical expedition to South America, any in that to the valley of the Amazon? Was there any in the sending out of parties for the observation of the total eclipses of the sun? It was by American astronomers that the true character of his corona was first determined. Was there any in the seven expeditions that were despatched for observing the transit of Venus? Was it not here that the bi-partition of Biela's comet was first detected, here that the eighth satellite of Saturn was discovered, here that the dusky ring of that planet, which had escaped the penetrating eye of Herschel and all the great European astronomers, was first seen? Was it not by an American telescope that the companion of Sirius, the brightest star in the heavens, was revealed, and the mathematical prediction of the cause of his perturbations verified? Was it not by a Yale College professor that the showers of shooting stars were first scientifically discussed, on the occasion of the grand American display of that meteoric phenomenon in 1833? Did we not join in the investigations respecting terrestrial magnetism instituted by European governments at the suggestion of Humboldt, and contribute our quota to the results obtained? Did not the Congress of the United States vote a money grant to carry into effect the invention of the electric telegraph? Does not the published flora of the United States show that something has been done in botany? Have not very important investigations been made here on the induction of magnetism in iron, the effect of magnetic currents on one another, the translation of quantity into intensity, and the converse? Was it not here that the radiations of incandescence were first investigated, the connection of increasing temperature with increasing refrangibility shown, the distribution of light, heat, and chemical activity in the solar spectrum ascertained, and some of the fundamental facts in spectrum analysis developed long before general attention was given to that subject in Europe? Here the first photograph of the moon was taken, here the first of the diffraction spectrum was produced, here the first portraits of the human face were made—an experiment that has given rise to an important industrial art!

Of our own special science, chemistry, it may truly be affirmed that nowhere are its most advanced ideas, its new conceptions, better understood or more eagerly received. But how useless would it be for me to attempt a description in these few moments of what Prof. Silliman, in the work to which I have already referred, found that he could not include on more than 100 closely printed pages, though he proposed merely to give the names of American chemists and the titles of their works. It would be equally useless and indeed an invidious task to offer a selection; but this may be said, that among the more prominent memoirs there are many not inferior to the foremost that the chemical literature of Europe can present. How unsatisfactory then is this brief statement I have made of what might be justly claimed for American science! Had it been ten times as long, and far more forcibly offered, it would still have fallen short of completeness. I still should have been open to the accusation of not having done justice to the subject.

Have those who gloat over the shortcomings of American science ever examined the Coast Survey Reports, those of the Naval Observatory, the Smithsonian Contributions, those of the American Association for the Advancement of Science, the Proceedings of the American Academy of Arts and Science, those of the American Philosophical Society, the Lyceum of Natural History, and our leading scientific periodicals? Have they ever looked at the numerous reports published by the authority of Congress on geographical, geological, engineering, and other subjects—reports often in imposing quartos magnificently illustrated.

Not without interest may we explore the origin of the depreciation of which we complain. In other countries it is commonly the case that each claims for itself all that it can, and often more than is its due. Each labors to bring its conspicuous men and its public acts into the most favorable point of view; each goes upon the maxim that a man is usually valued at the value he puts upon himself. But how is it with us? Can an impartial person read without pain the characters which we so often attribute to our most illustrious citizens in political, and what is worse, in social life? Can we complain if strangers accept us at our own depreciation, whether of men or things?

We need not go far to detect the origin of all this—it is in our political condition. Here wealth, power, preferment—preferment even to the highest position in the nation—are seemingly within the reach of all, and in the internecine struggle that takes place every man is occupied in pushing some other man into the background. I fear that in political life there is no remedy for this, such is the violence of the competition, so great are the prizes at stake. But in the less turbulent domain of science and letters we may hope for better things. And those who make it their practice to decry the contributions of their own country to the stock of knowledge may perhaps stand rebuked by the expressions that sometimes fall from her generous rivals. How can they read without blushing at their own conduct such declarations as that recently uttered by the great organ of English opinion, the foremost of English journals? The Times, which no one will accuse of partiality in this instance, says: "In the natural distribution of subjects, the history of enterprise, discovery, and conquest, and the growth of republics fell to America, and she has dealt nobly with them. In the wider and multifarious provinces of art and science she runs neck and neck with the mother country and is never left behind!"

There are among us some persons who depreciate science merely through illiterate arrogance; there are some who, incited by superficiality, dislike it; there are some who regard it with an evil eye, because they think it is undermining the placid tranquillity they find in lifelong cherished opinions. There are some who hate it because they fear it, and many because they find that it is in conflict with their interests. But let us who are the servants of science, who have dedicated ourselves to her, take courage. Day by day the number of those who hold her in disfavor is diminishing. We can disregard their misrepresentations and maledictions. Mankind has made the great discovery that she is the long hoped-for civilizing agent of the world. Let us continue our labor unobtrusively, conscious of the integrity of our motives, conscious of the portentous change which is taking place in the thought of the world, conscious of the irresistible power which is behind us! Let us not return railing for railing, but above all, let us deliver unflinchingly to others the truths that Nature has delivered to us!

The book of Nature! shall not we chemists, and all our brother-students, whether they be naturalists, astronomers, mathematicians, geologists, shall we not all humbly and earnestly read it? Nature, the mother of us all, has inscribed her unfading, her eternal record on the canopy of the skies, she has put it all around us on the platform of the earth! No man can tamper with it, no man can interpolate or falsify it for his own ends. She does not command us what to do, nor order us what to think. She only invites us to look around. For those who reject her she has in reserve no revenges, no social ostracism, no *index expurgatorius*, or *auto da fé!* To those who in purity of spirit worship in her heaven-pavilioned temple, she offers her guidance to that cloudy shrine on which Truth sits enthroned, "dark with the excess of light!" Thither are repairing, not driven by tyranny, but of their own accord, increasing crowds from all countries of the earth, conscious that whatever their dissentions of opinion may heretofore have been, in her presence they will find intellectual concord and unity.

13. *Prof. Draper's researches in Physics.*—Prof. Draper's researches are a very prominent part of the scientific work of the country. We cite the following from the Address of the President of the American Academy of Arts and Sciences, in March last, on the presentation to Prof. Draper of the Rumford medals. —Eds.

In an elaborate investigation, published in 1847, Dr. Draper established experimentally the following important facts: 1. All solid substances, and probably liquids, become incandescent at the same temperature. 2. The thermometric point at which substances become red-hot is about 977° Fahr. 3. The spectrum of an incandescent solid is continuous; it contains neither bright nor dark fixed lines. 4. From common temperatures nearly up to 977° Fahr., the rays emitted by a solid are invisible. At that temperature they are red, and the heat of the incandescing body being made continuously to increase, other rays are added, increasing in refrangibility as the temperature rises. 5. While the addition of rays, so much the more refrangible as the temperature is higher, is taking place, there is an increase in the intensity of those already existing. Thirteen years afterward Kirchhoff published his celebrated memoir on the relations between the coefficients of emission and absorption of bodies for light and heat, in which he established mathematically the same facts, and announced them as new. 6. Dr. Draper claims, and we believe with justice, to have been the first to apply the daguerreotype process to taking portraits. 7. Dr. Draper applied ruled glasses and specula to produce spectra for the study of the chemical action of light. The employment of ruled metallic specula for this purpose enabled him to avoid the absorbent action of glass and other transparent media, as well as to establish the points of maximum and minimum intensity with reference to portions of the spectrum defined by their wave lengths. He obtained also the advantage of employing a normal spectrum in place of one which is abnormally condensed at one end and expanded at the other. 8. We owe to him valuable and original researches on the nature of the rays absorbed in the growth of plants in sunlight. These researches prove that the maximum action is produced by the yellow rays, and they have been fully confirmed by more recent investigations. 9. We owe to him, further, an elaborate discussion of the chemical action of light, supported in a great measure by his own experiments, and proving conclusively, and, as we believe, for the first time, that rays of all wave-lengths are capable of producing chemical changes, and that too little account has hitherto been taken of the nature of the substance in which the decomposition is produced. 10. Finally, Dr. Draper has recently published researches on the distribution of heat in the spectrum, which are of the highest interest, and which have largely contributed to the advancement of our knowledge of the subject of radiant energy.

II. GEOLOGY AND MINERALOGY.

1. *Explorations made under the direction of F. V. Hayden, in* 1876.—For reasons beyond the control of the Geologist in charge, the various parties composing the United States Geological and Geographical Survey of the Territories, did not commence their field work until August. Owing to the evidence of hostility among the northern tribes of Indians it was deemed most prudent to confine the labors of the survey to the completion of the Atlas of Colorado. Therefore the work of the season of 1876 was a continuation of the labors of the three preceding years, westward, finishing the entire mountainous portion of Colorado with a belt fifteen miles in width of northern New Mexico and a belt twenty-five miles in breadth of eastern Utah. Six sheets of the Physical Atlas are now nearly ready to be issued from the press. Each sheet embraces an area of over 11,500 square miles, or a total of 70,000 square miles. The maps are constructed on a scale of four miles to one inch with contours of 200 feet, which will form the basis on which will be represented the geology, etc. The areas of exploration the last season are located in the interior of the continent, far remote from settlements and among the hostile bands of Ute Indians that attacked two of the parties the previous year.

Five parties were engaged in field duty: one for completing the primary triangulation of Colorado, three for topographical and geological work, and one for making observations in natural history.

The primary triangulation party was placed in charge of A. D. Wilson and took the field from Trinidad, the southern terminus of the Denver and Rio Grande Railway, August 18th, making the first station on Fisher's Peak. From this point the party marched by the valley of the Purgatoire, crossed the Sangre de Christo range by way of Costillia Pass, followed the west base of the range northward as far as Fort Garland, making a station on Culebra Peak. About six miles north of Fort Garland is located one of the highest and most rugged mountain peaks in the west, called Blanca Peak, the principal summit of the Sierra Blanca group. This was ascended by the party under Mr. Wilson, and found to be the highest peak in Colorado and the second peak in height in the United States. A comparison with some of the first class peaks in Colorado will show the relative heights.

Blanca Peak	above sea level,	14,464 feet.
Mt. Harvard	" "	14,384 "
Gray's Peak	" "	14,341 "
Mt. Lincoln	" "	14,296 "
Mt. Wilson	" "	14,280 "
Long's Peak	" "	14,271 "
Uncompahgre Peak	" "	14,235 "
Pike's Peak	" "	14,146 "

Mr. Wilson made eleven primary stations over a large portion of Southern and Western Colorado and completed about 1,000 square miles of topography that had been omitted by one of the parties of last year.

In company with the triangulation party, Mr. Holmes made a hurried trip through Colorado, touching also portions of New Mexico and Utah. He was unable to pay much attention to detailed work, but had an excellent opportunity of taking a general view of the two great plain belts that lie, the one along the east, the other along the west base of the Rocky Mountains. For nearly 2,000 miles travel he had constantly in view the Cretaceous and Tertiary formations, among which are involved some of the most interesting geological questions. He observed among other things the great persistency of the various groups of rocks throughout the east, west and north, and especially in the west; that from Northern New Mexico to Southern Wyoming the various members of the Cretaceous lie in almost unbroken belts, while the Tertiaries are hardly less easily followed.

Between the east and the west there is only one great incongruity. Along the east base of the mountains the upper Cretaceous rocks, including Nos. 4 and 5, are almost wanting and consisting at most of a few hundred feet of shales and laminated sandstones. Along the west base this group becomes a prominent and important topographical as well as geological feature. In the southwest, where it forms the "Mesa Verde" and the cap of the Dolores plateau, it comprises upward of 2,000 feet of coal-bearing strata, chiefly sandstones, while in the north it reaches a thickness of 3,500 feet and forms the gigantic hog-back of the Grand River valley.

While in the southwest, he visited the Sierra Abajo, a small group of mountains which lie in Eastern Utah, and found as he had previously surmised that the structure was identical with that of the four other isolated groups that lie in the same region. A mass of trachyte has been forced up through fissures in the sedimentary rocks and now rests chiefly upon the sandstones and shales of the lower Cretaceous. There is a considerable amount of arching of the sedimentary rocks, caused probably by the intrusion of wedge-like sheets of trachyte, while the broken edges of the beds are frequently bent abruptly up as if by the upward or lateral pressure of the rising mass. He was able to make many additional observations on the geology of the San Juan region, and secured much valuable material for the coloring of the final map.

He states that the northern limit of ancient cliff builders in Colorado and Eastern Utah is hardly above latitude 37° 45′.

The Grand River Division was directed by Henry Gannett, topographer, with Dr. A. C. Peale as geologist. James Stevenson, executive officer of the survey, accompanied this division for the purpose of assisting in the management of the Indians, who last year prevented the completion of the work in this locality by their hostility.

The work assigned this division consisted in part of a small area containing about 1,000 square miles lying south of the Sierra la Sal. The greater portion of the work of this division lay north of the Grand River, limited on the north by the parallel of 39° 30′ and included between the meridians of 108° 00′ and 109° 30′.

The geological work of this division, by Dr. Peale, connects directly with that done by him in 1874 and 1875. Sedimentary formations prevail in both districts visited during the past season.

The country first examined lies between the San Miguel and Dolores Rivers, extending northward and northwestward from Lone Cone Mountain. The general character of this region is that of a plateau cut by deep gorges or cañons, some of which, especially toward the north, extend from the sandstones of the Dakota group to the top of the Red Beds. The depth of the cañon however is no indication of its importance as a stream bed, for away from the main streams they are dry the greater portion of the year. There are no great disturbances of the strata, what folds do occur being broad and comparatively gentle.

The San Miguel River leaving the San Juan Mountains flows toward the northwest and, with its tributaries, cuts through the sandstones of the Dakota group, exposing the variegated beds lying beneath that have generally been referred to the Jurassic. About twenty-five or thirty miles north of Lone Cone, the river turns abruptly to the west and flows west and southwest for about fifteen miles, when it again turns and flows generally northwest until it joins the Dolores. Between the San Miguel and

Lone Cone the sandstones of the Dakota group or No. 1 Cretaceous are nearly horizontal, forming a plateau which on approaching the mountains has a capping of Cretaceous shales.

Beyond the bend, the San Miguel flows in a monoclinal valley in which the cañon walls are of the same description as in the upper part of its course. As the mouth is approached the Red Beds appear. Between this portion of the course of the San Miguel and the almost paralled course of the Dolores, which is in a similar monoclinal rift, there are two anticlinal and two synclinal valleys parallel to each other. They are all occupied by branches of the Dolores. Lower Cretaceous, Jurassic and Triassic strata outcrop and present some interesting geological details which will be fully considered in the report on the district. The Dolores river comes from a high plateau in a zigzag course, flowing sometimes with the strike and sometimes with the dip of the strata. Its general course on the western line is about northwest from which it turns to the northward and westward, finally changing to northwest again to its junction with the Grand. It is in a cañon the greater part of its course.

In the region of country north of Grand River, the geological formations extend uninterruptedly from the Red Beds exposed on Grand River to the White Tertiary cliffs forming the summit of of the "Roan Mountains" or Book Cliffs. The Grand is generally in a cañon in the Red Beds. On the north side the No. 1 Cretaceous sandstones form a hogback sloping toward the cliffs. Between the crest of this hogback and the cliffs, there is a broad valley formed by the erosion of the soft Cretaceous shales which extend to the base of the cliffs and in some places form their lower portion.

The cliffs are composed mainly of Cretaceous beds, rising one above another in steps, until an elevation of about 8,000 feet is reached. The summit is the edge of a plateau, sloping to N.N.E. This plateau is cut by the drainage flowing into the White River from the south. These streams rarely cut through the Tertiary series.

Coal of poor quality is found in the sandstones of the Dakota group and also in the sandstones above the middle Cretaceous beds. Wherever noticed it was in thin seams and of little economic importance.

The White River division was directed by G. B. Chittenden as topographer, accompained by F. M. Endlich as geologist.

The district assigned to this party as their field for exploration during the season of 1876, commenced from the eastward at longitude 107° 30′, joining on to the work previously done and extended westward 30 miles into Utah Territory. Its southern boundary was N. latitude 39° 30′, while the White River formed the northern limit. In order to complete the work to the greatest possible advantage in the shortest time that could be allowed, it was determined to make the White River Agency headquarters, and in two trips from there complete the work. About 3,800 square miles comprised the area surveyed.

According to the report of F. M. Endlich, the geology of the district is very simple though interesting. Inasmuch as but one divide of importance occurred within the district, the work was somewhat simplified. This was formed by the "Book Cliffs," between the drainage of the Grand on the south and the White on the north. Both of these rivers flow a little south of west, into the Green River which they join in Utah. From the junction of the Grand and Green downward the river is called the Great Colorado. Orographically, the region surveyed is comparatively simple. The "Book Cliffs" are the summit of a plateau about 8,000 feet above sea level, continuing unbroken over to the Green River. Toward the south these cliffs fall off very steeply, forming deep cañons that contain tributaries of the Grand River. On the north side—with the dip of the strata—the slope is more gentle, although in consequence of erosion numerous precipitous cliffs are formed. Descending in that direction the character of the country changes. Instead of an unbroken slope, we find that the plateau has been cut parallel by the White River drainage, and the long, characteristic mesas of that region testify to the action of erosion. Approaching the river, constantly descending with the slight dip of the strata, the bluffs become lower and lower. Though the creek valleys are wide and at certain seasons no doubt well watered, the vegetation is that of an arid country. Dwarf pines, piñons and sage brush abound, to the almost entire exclusion of other trees or grass. Traveling down White River this character is again found to change. A new series of bluffs, occasioned by heavy superincumbent strata, gives rise to the formation of deep cañons. For 45 miles the party followed the cañon of White River, that, no doubt, is analogous to that of Green River, and probably closely resembles that of the Colorado in its detail features. Vertical walls enclose the narrow river-bottoms, and the slopes of the higher portions are ornamented by thousands of curiously eroded rocks. Monuments of all kinds and figures that can readily be compared to those of animated beings enliven the scenery, which would otherwise be monotonous Two to three thousand feet may be stated as the height of the walls enclosing the White River.

Geologically speaking, the district was one of singular uniformity. Traveling westward, the older formations, reaching back as far as the Jurassic, were found. These were followed by Cretaceous which in turn was covered with Tertiary. About three-quarters of the region surveyed was found to contain beds belonging to this period. Owing to the lithographical character of the strata, water was a rare luxury in this region, and men and animals were frequently dependent upon springs. Farther west still, the Green River group sets in, forming those numerous cañons of which that of the White River is one.

The field work of the Yampah division, under Mr. G. R. Bechler as topographer and Dr. C. A. White as geologist, during the past season was principally confined to a district of northwestern Colorado lying between the Yampah and White Rivers, and between Green River and the subordinate range of mountains that lies west of and parallel with the Park Range. The area is embraced between parallels 39° 30′ and 40° 30′, and meridians 107° 30′ and 109° 30′.

The rocks of this district embrace all the sedimentary formations yet recognized by the investigators who have studied the region that lies between the Park Range and the Great Salt Lake, namely from the Uinta Quartzite (which underlies the Carboniferous) to the latest Tertiary, inclusive. Not only has the geographical distribution of these formations been mapped, but all the displacements of the strata have been traced and delineated. The last named investigations bring out some interesting and important facts, in relation to the orographic geology of the region, especially as regards the eastern termination of the great Uinta uplift and the blending of its vanishing primary and accessory displacements with those of the north and south range above mentioned. Much information was also obtained concerning the distribution of the local drift of that region; the extent and geological date of outflows of trap, etc.

The brackish water beds at the base of the Tertiary series, containing the characteristic fossils, were discovered in the valley of the Yampah. They are thus shown to be exactly equivalent with those now so well known, in the valley of Bitter Creek, Wyoming Territory. These last named localities were also visited at the close of the season's work, and from the strata of this horizon at Black Buttes station, three new species of *Unio* were obtained, making six clearly distinct species in all that have been obtained associated together in one stratum at that locality. They are all of either distinctively American types or closely related to species now living in American fresh waters. They represent, by their affinities, the following living species; *Unio clavus* Lamarck; *U. securis* Lea; *U. gibbosus* Barnes; *U. metanevrus* Rafinesque, and *U. complanatus* Solander. They are associated in the same stratum with species of the genera *Corbula*, *Corbicula*, *Neritina*, *Viviparus*, etc., and which stratum alternates with layers containing *Ostrea* and *Anomia*.

The close affinity of these fossil *Unios* with species now living in the Mississippi River and its tributaries, seems plainly suggestive of the fact that they represent the ancestry of the living ones. An interesting series of facts has also been collected, showing that some of the so-called American types of *Unio* were introduced in what is now the great Rocky Mountain region, as early as the Jurassic period, and that their differentiation had become great and clearly defined as early as late Cretaceous and early Tertiary times. Other observations suggest the probable lines of geographical distribution, during the late geological periods, of their evolutional descent, by one or more of which they have probably reached the Mississippi River system and culminated in the numerous and diverse forms that now exist there.

The work of the past season shows very clearly the harmonious relation of the various groups of strata over vast areas, that although there may be a thickening or a thinning out of beds at different points, they can all be correlated from the Missouri River to the Sierra Nevada Basin. The fact also that there is no physical or paleontological break in these groups over large areas, from the Cretaceous to the middle Tertiary is fully established. The transition from marine to brackish water forms of life, commences at the close of the Cretaceous epoch and, without any line of separation that can yet be detected, continues on upward until only purely fresh water forms are to be found. Dr. White, an eminent paleontologist and geologist says that the line must be drawn somewhere between the Cretaceous and Tertiary epochs, but that it will be strictly arbitrary, as there is no physical break to the summit of the Bridger group. H.

2. *Geological Survey of Kentucky.*—Chemical examination of the Ashes of the Hemp and Buckwheat Plants, with remarks on its bearing on Hemp Culture in Kentucky, by R. Peter, M.D., Chemist to the Survey. Publications of the Geological Survey of Kentucky under N. S. Shaler, Director. Part III, vol. ii. Second Series. 25 pp. 8vo. Frankfort, Kentucky.—The following remarks on hemp and the analyses are copied from pages 11 to 13 of this Report. "In order to ascertain the relative fertilizing influence of the leaves and roots, three hemp plants were collected, July 25th, 1864, in *the dry season.* These, one male and two female plants, were about six to seven feet high. The leaves, stems and roots, carefully separated and thoroughly air dried, weighed as follows:

The leaves weighed 23·916 grams, equal to about 30· per cent of the whole plant.
The roots " 7·433 " " 9·3 " " "
The stems " 48·430 " " 60·7 " " "

These were separately incinerated and their ashes analyzed, with the following results:

RELATIVE ASH INGREDIENTS OF THE LEAVES, ROOTS, AND STEMS OF THE HEMP, CARBONIC ACID EXCLUDED.

	THE LEAVES.		THE STEMS.		THE ROOTS.	
	In 100 p'ts of ash.	In 100 p'ts of dried leaves.	In 100 p'ts of ash.	In 100 p'ts of dried stems.	In 100 p'ts of ash.	In 100 p'ts of dried roots.
Lime	48·819	4·992	23·371	0·949	20·368	0·713
Magnesia	5·726	·585	5·803	·194	8·297	·291
Potash	27·955	2·858	49·599	1·659	52·233	1·829
Soda	·236	·024				
Phosphoric acid	9·264	·947	13·374	·447	15·164	·531
Sulphuric acid	2·209	·226	1·215	·040	1·344	·047
Chlorine	·171	·017	·576	·019	·405	·014
Silica	5·620	·575	1·062	·035	2·189	·077
Per cent of phosphates	19·160	1·959	28·158	0·942	26·885	0·949
Per cent of ash	....	10·225	....	3·346	....	3·502

By examination of the above table it is to be seen, that the leaves of the flowering hemp contain more of the essential mineral ingredients of the soil than all the other parts of the plant; constituting as they do, about 30 per cent of the whole plant in the air-dried state, and yielding 10·225 per cent of their weight of ash, the carbonic acid being excluded; while the stems and roots, which together form the remaining 70 per cent of the weight of the plant, give an average of less than 3·5 per cent of ash.

Nor is this great excess in the proportion of ash in the leaves due entirely to the influence of the greater evaporation which takes place on their surfaces, causing a deposit or incrustation of lime and magnesia salts and silica of the nature of stalagmite; for we see that while the amount of *silica* in the leaves is nearly fourteen times greater than that in the stems, and more than seven times greater than in the roots; the *lime* more than five times as great as that in the stems, and seven times more than in the roots; the *magnesia* three times more than that in the stems, and twice as much as that in the roots; the *phosphoric acid* and *phosphates* and the *alkalies* are in nearly double proportion in the leaves also, and the sulphuric acid five times greater in them than in the stems, and about four times greater than in the roots. So that while the leaves, when in their fully matured state or when they naturally fall, may possibly contain scarcely any but the less soluble salts which may be left in their tissues on the evaporation of the carbonated water which held them in solution in the sap, they contain, when in the growing, active condition, like all other green herbage, a very large proportion of salts of potash, and of all the mineral elements of plant nourishment, and hence may greatly enrich the soil on which they decay. It is obviously to the interest of the hemp farmer, therefore, so to manage as to spread them as regularly as possible over his hemp ground.

3. *The American Bison, Living and Extinct;* by J. A. ALLEN. Published, by permission of N. S. Shaler, Director of the Kentucky Geological Survey, as vol. iv, No. 10, of the Memoirs of the Museum of Comparative Zoology at Harvard College. Cambridge, Mass. 246 pp. 4to, with 12 plates and a colored map. (Welch, Bigelow & Co.).—This work, beautiful in typography, as well as in its illustrations, is a carefully prepared monograph of the American bisons, containing, as its first part, descriptions of the species, and, as its second, a thorough discussion of their geographical distribution. Two extinct species are recognized, *Bison latifrons* Leidy, and *B. antiquus* Leidy (= *B. crassicornis* Richardson). To the description of *Bison Americanus* the author has added much information on the habits of the species from his own observations. The fine colored map is introduced to illustrate its former and present distribution.

4. *Second Geological Survey of Pennsylvania.* Harrisburg, Pa.

(1.) Report of Progress in the Greene and Washington District of the Bituminous Coal-fields of Western Pennsylvania, by J. J.

STEVENSON. 420 pp. 8vo, with 3 sections and 2 County maps, showing the calculated local depths of the Pittsburg and W.

(2.) Report of Progress in the District of York and Adams Counties. 196 pp. 8vo, with Maps and Cross-sections showing the Iron-ore belts and individual Mines; by PERSIFOR FRAZER, JR.

Mr. Stevenson's Report, after chapters on the physical features of the district and its Quaternary geology, describes in detail the Carboniferous strata, their nature, positions and relations, and then takes up the special geology of the several townships, giving numerous sections, and much information on the coal beds and coals. The closing chapter, on Economic Geology, contains information as to the thickness and variations of the coal beds, the composition of coals, constitution and value of the iron-ores, and on the distribution and source of the petroleum of the district. Mr. Stevenson concludes, with regard to the oil, that it has not arisen from the distillation of shales, but that "it is in the highest degree probable that the vegetable matter [that of the oil-bearing sandstone beds] instead of being converted into coal was converted into petroleum, and that the oil is indigenous to these sandstones."

The Terraces of the Ohio and Alleghany valleys are described as generally well defined. The upper is of various heights, 180, 250, and even 480 feet. From Monongahela to Pittsburg terraces are stated to be very distinct at 190 and 290 feet; while at the former place there are seven terraces at 40, 120, 190, 290, 340, 400, and 480 feet; and below Pittsburg, at Chartiers, there are six, the highest 390 feet. They indicate great height in those valleys for the Glacial flood, when water and earthy material were both, for a long period, of indefinite supply from the melting of the glacier.

Mr. Frazer treats of a belt in Eastern Pennsylvania which includes numerous limonite beds associated with granular limestone and hydromica slates, similar in character and position to those characterizing the Green Mountain region in Berkshire, Mass., and Salisbury, Connecticut, and the adjoining parts of New York, and also in Vermont. The relative position of the rocks is made a special study, and several sections presenting the author's present views on this subject are given, though with some expressions of uncertainty. The main point set forth is that the limestones and slates are not conformable—which is at variance with most (not all) of the sections observed by the writer in Berkshire. The volume also contains descriptions of some trap rocks, analyses of hydromica slates, limestones, and detailed descriptions and analyses of iron ores.

5. *On the Glacial Phenomena of North America;* by Professor OTTO TORELL, of Sweden. (Proc. Amer. Assoc., Buffalo.)—The following is a report of the paper by Professor Torell in the New York Times of August 30.—It may be assumed that the circumstances essential to the formation and movement of glaciers are these: 1. Abundance of moisture in the atmosphere; 2. A low temperature, due either to great elevations in low latitudes, or to

high latitudes with or without such elevations of land. These conditions insure such accumulations of snow above the line of perpetual frost as will sooner or later pass the line of perpetual snow and be changed to ice and water. The water becomes glacial rivers, and the ice will move as a plastic mass to a line determined by the amount of snow, on the one hand, and the climate on the other. The advancing movement of the glacier is accompanied by erosion and scratching of the rocks below and by the different kinds of moraines, as till or blue bowlder clay, and yellow unstratified masses—terminal, lateral, and superficial moraines. Simultaneous with these phenomena we have this action of the glacial river, namely, a partial denudation of the moraines, and the formation of stratified gravel, sand, and clay.

The glacial phenomena of the Glacial period were as follows: 1. The sinking of the temperature, accompanied by the formation and increase of glaciers; 2. The motion of the ice to its extreme limit; 3. The formation of moraines, of which a part were moved forward and constituted terminal moraines, while another portion was passed over by the ice, and then became bottom or ground moraines; 4. The removal by this advancing glacier of the glacial river deposits, or the covering of them by the glacier itself and its ground moraine. A geological section of the edge of the ice would then present either (*a*) preglacial beds; (*b*) stratified glacial deposits; (*c*) a ground moraine; (*d*) the ice with its terminal moraine: or (*a*) scratched rocks; (*c*) a ground moraine; (*d*) ice and terminal moraines. The first-named section is most common in the portions of Europe covered by Scandinavian erratics. The second is found generally in Scandinavia and in the United States.

The retrograde movement of a glacier during the period of melting is characterized: 1. By the formations of upper or terminal moraines, which are more or less leveled by local backward and forward movements of a glacier during successive intervals of time; 2. By stratified river deposits lying upon the unstratified yellow moraine, so that a section above the sections just described will present (*a*) preglacial beds; (*b*) stratified deposits; (*c*) till or ground moraine; (*d*) terminal moraines leveled down to great fields containing unstratified materials; (*e*) stratified beds formed by glacial rivers with gradually descending sources. The characteristics of deposits (*b*) are that only in the vicinity of high mountains they contain rounded stones, while farther away they consist of deposits of sand and clay. The characteristics of the deposits (*c*) are: A blue color, due to the seclusion from the oxidizing action of the air; compactness and hardness; rounded form of the bowlders, which are polished and scratched, and also generally brought from remote places. The characteristics of the deposits (*d*) are: A yellow and reddish color, occasioned by peroxidation of iron, comparative looseness of the mass, and greater angularity of the bowlders, which are rarely scratched, and usually belong to neighboring localities. The characteristics of the deposits (*e*) are: Stratification, abundance of rounded and unscratched bowlders; they generally consist of beds of gravel and sand, without clay. These phenomena are found not only in Europe wherever there are traces of the ice age, but are observable in the United States and in the region to the north of them. Each glacier has had its own limited area, and the same appears to have been the case with all the great drift deposits in North America. The greatest ice-field of Europe was that which originated in the highlands of Scandinavia, and thence extended over those portions of Northern Europe which are known to be covered by Scandinavian erratics.

By investigations extending through a long period of years, I have found that the above-mentioned glacial beds or deposits exist in all the countries above indicated. The Scandinavian glacier crossed the Baltic and German Ocean, and extended its moraines into the suburbs of London on the west, to the slopes of the Riesengebirge in the southeast, to the Tjernaye Bay, the icy, on the northeast. The presence of precisely similar phenomena in North America has established in the minds of a majority of geologists the conviction that a vast area over which such phenomena are found has also been covered with ice. But if we carefully examine this region it will readily appear that the glacial area is not continuous from ocean to ocean, but it is divisible into a northwestern area, and the Rocky Mountain area and others to the west, separated by a broad, driftless belt extending from the base of the Rocky Mountains nearly to the Mississippi, thus forcing the conclusion that the great Eastern and Western ice-fields have had different sources.

It has been the opinion of many distinguished American geologists that the source of the eastern ice-fields is to be sought in the Canadian highlands. Against this opinion several important reasons may be urged. First, in the portions of Canada in which the glaciers in question are supposed to have originated, we have reason to believe that the rocks are rounded and scratched, phenomena everywhere recognized as glacial; but I think in no case characterizing rocks known to have been covered with perpetual snow. Again, the elevation and extent of the highest portions of Canada are hardly sufficient to account for the requisite accumulation of snow and ice. And finally, so far as I have learned, there is not formed upon the rocks of the northern slope of Canada, nor yet in bowlders moved by glacial force, any satisfactory evidence that there had been a northward as well as southward movement of glaciers from the highlands of Canada. If, therefore, the phenomenon of the northern and eastern United States, usually supposed to be glacial, are indeed such, and if there is not sufficient reason for assuming the Canadian highlands to have been the source of the glaciers which produced these phenomena, then the source of them must be sought for elsewhere.

I think it will be conceded by all geologists who have studied the glacial phenomena of these regions that both the character of the erratics and the direction of the scratches upon the rocks show that this source must lie to the northeast. Following the line of the glacial movement across Baffin's Bay and Davis' Strait to Greenland, we find that the largest body of land in the northern hemisphere, covered by ice and snow to a depth of not less than 2,000 feet, and at this moment sending down its icebergs as far as the Middle Atlantic. From the sixtieth degree of latitude to above the eightieth, this vast area of land is known to be ice-covered, and from the scarcity of the icebergs upon the eastern compared with the western coast of that land, it may be concluded that the general slope of the surface is to the southwest, and in exact direction of the glacial markings of what is known to have been the course of transported bowlders in Northeastern America. Moreover, if we bear in mind the certainty that during the Glacial period the glaciers moving from the heights of Greenland toward the sea could not have formed detached icebergs as now, but must have for the time blocked up all avenues except the one of easiest escape for the immense accumulations of ice, we may easily assume that this avenue was southwestward across British America and the northeastern part of the United States.

Finally, it may be remarked that this view is strongly confirmed by comparison of the Scandinavian with the American glacial area, for in addition to the identity of the general phenomena there is observable a marked resemblance in the proportion between the extent and other circumstances of the two areas, and that by allowing due weight to all the evidences adduced in support of the view that Greenland was the source of the glacial phenomena of the area in question, we find a probable and rational solution of a hitherto unsettled problem.

6. *Note on the Glacial era;* by JAMES D. DANA.—Professor Torell, in his important paper on the Glacial phenomena of North America, supposes that we differ in our views. It is a pleasure to know that we agree in all essential points. No American geologist holds, so far as I know, that "the source of the eastern ice-fields of North America is to be sought in the Canadian highlands." In my papers on this subject in this Journal for 1871 (ii, 324) and 1873 (v, 204), I was speaking of the "Glacier of New England," that is, the New England part of the great glacier; and, the conclusion arrived at was that the glacial scratches over New England, New York, and the region of Canada just north, *converge* toward an area on the Canadian watershed; and hence that the movement over New England and New York diverged from this area. I say that "the scratches of Eastern Canada, of the high land of Northern New England, of Eastern and Western New York, and of Northwestern Canada, point to a part of the Canada water-shed between the St. Lawrence Valley and Hudson Bay as the head of the glacier that moved southeastwardly over New England." I regret that my words were in any

way calculated to mislead. Professor Torell corrects the above view by making Greenland the great source; but to put Greenland in the above sentence would make it absurd, for no height of ice in that land, so far to the northeast, could have determined *southeastward movements over New England.* I did not doubt that the ice mass of the Canada water-shed, continued northward or northeastward, in the direction of the region of greatest precipitation, as the chief ice-mass of the continent; but only whether the increase of height in that direction exceeded enough that on the water-shed to cause movements in the directions indicated. I concluded that the height of the ice-surface on the water-shed would have had to have been at least 13,000 feet to have given it a slope of even fifteen feet a mile to its discharge in the ocean south and east of New England and ten feet a mile to the ice-surface over Mount Washington—the smallest pitch that seemed to be capable of producing the southward and southeastward movement; and the adding of ten feet a mile to the height farther north, thus increasing this already incredible altitude I allude to (ii, 328) but with an improbable *if*. The region of greatest height to the north of the water-shed I did not consider, because it was not within the range of my subject—the source of the "New England Glacier;" and I had no satisfactory facts as to the present amount of precipitation to the north, much less any data for judging of the hygrometric condition in the Glacial era.

In this Journal for April, 1875 (ix, 312), in citing facts from Dr. Bell, in the Report of the Canada Geological Survey for 1873-4, I observe that the facts from the vicinity of Lake Winnipeg show that a line of greatest glacier height was continued from the ice-summit on the Canada water-shed northward; but not necessarily that the height northward "was as great as over the water-shed," for "the greatest height would have been where there was the greatest amount of precipitation, supposing the melting the same." I then explain the absence of the glacier from the central regions of the continent (exclusive of the Rocky Mountains) by reference to the small amount of precipitation (referring to Schott's Rain-chart), and to the high degree of summer heat, thus making the glacier, as I state, a great coastward ice-mass, thinning out to the westward; and the Continental ice, not an ice-cap, but, as I say in a subsequent note (x, 385, 1875), an "ice-mantle thrown about the pole and descending along the borders of the Continent, especially the eastern."

6. *A monograph of American Trilobites;* by A. W. Vogdes, U. S. Army. 16 pp. Tampa, Florida.—This pamphlet is Part I of Lieut. Vogdes' monograph. It is wholly bibliographical, giving the general bibliography on the subject, from the first paper, in 1698, by Lhwyd, and then, references to the works or memoirs that treat of the several species of the genera *Asaphus*, *Odontopleura* (Acidaspis), *Proëtus*, *Bathyurus*, *Bathyurellus*, *Agraulos*, *Ptychoparia* (Conocephalites), and *Ceraurus*.

8. *An outline of the Geology of Canada*, based on a subdivision of the Provinces into natural areas; by E. J. CHAPMAN, Prof. Min. and Geol., University College, Toronto, Canada. 106 pp. 8vo, with several maps and plates of fossils.—Prof. Chapman's work is a brief resumé of the facts in Canadian geology, preceded by an Introduction, of 32 pages, on rock-formations and divisions of geological time. The work is a convenient one for the student and also for the geologist who would acquire a general knowledge of British-American Geology. It contains six plates of fossils representing Canadian species.

9. *Origin of Forest and Prairie regions.*—Prof. J. D. Whitney has a valuable paper on this subject in the American Naturalist for October and November.

10. *The Great Ice Age and its relations to the Antiquity of Man*, by JAMES GEIKIE, F.R.S., of H. M. Geological Survey of Scotland. 2d edit. revised. 624 pp. 8vo, with several maps and numerous illustrations. London, 1877. (Daldy, Isbister & Co.).—In this second edition, Prof. Geikie's very popular work has received various additions from recent observations, partly personal, made in Britain, and from researches in other countries, America included; and, as the author's preface states, much of it has been rewritten. The subject is well treated in all its different branches, and the illustrations are excellent. The maps include one of North America, showing the southern outline of the glacier and the general courses of erosion. Among the changes of views introduced, are the use now of the terms till and bowlder clay "as strictly synonymous;" and the adoption of the conclusion of Mr. Jamieson, that "the sea had not any share in the formation of the kames." The work is the best review of the subject to be had, and owes much of its value to Professor Geikie's own researches.

III. BOTANY AND ZOOLOGY.

1. *Date of Publication of Elliott's Botany of South Carolina and Georgia.*—The title-page of the first volume bears the date of 1821. But it is well known that the work was issued in parts, and that the publication began much earlier. The actual time of issue becomes important in respect to the priority of certain generic and specific names, notably those in Nuttall's *Genera*, published in 1818. Contrary to the testimony of the title-pages, it is generally understood that Elliott's names of *Podostigma* and *Acerates* have priority over Nuttall's *Stylandra* and *Anantherix*. To avoid future trouble it is desirable to put upon record such evidence upon the point as is now obtainable. The only printed testimony yet met with is in the *Reliquiæ Baldwinianæ*, the correspondence of Dr. Wm. Baldwin (Elliott's ablest collaborator), lovingly edited by his friend, Dr. Darlington. By reference to pp. 202, 248, 249, and 585, it is made out that the first number of Elliott's work was issued as early as October, 1816, was recalled, reprinted, and issued anew, along with the second number, before

January, 1817. The first number probably ended on p. 96; the second on p. 222. The third and fourth numbers were published before November 10, 1817. The fourth number must have included p. 466; the fifth and concluding number of the volume (to which the title-page assigns the date of 1821), must begin on or before p. 529. For, on the latter page Nuttall's genus *Diamorpha* occurs, and his work is for the first time cited; while the prefatory list of decandrous genera, on p. 466, does not contain *Diamorpha.*

This is confirmed by Elliott's correspondence with Zaccheus Collins, now in the possession of the Academy of Natural Sciences, Philadelphia, which Mr. Redfield has kindly consulted, at my request; from which it appears, in short, that No. 1 was first issued, September 26, 1816; No. 2, on or before February 19, 1817; No. 3, on or before April 3, 1817; No. 4 and No. 5, no data found; No. 6, the commencement of the second volume, appeared on or before October 12, 1821. The title page of this volume bears the date of 1824.

The collection referred to, and which contains a series of letters of Muhlenberg, Elliott, Bigelow, Torrey, and others, to Collins, has been put into excellent condition for preservation by Mr. John H. Redfield. A hasty perusal shows that it is replete with interest. It would be well if the Philadelphia Academy would print it, or at least portions of it, with some editorial notes which could now be supplied, but for which it may now ere long be too late. A. G.

2. *Homogone and Heterogone* (*or Homogonous and Heterogonous*) *Flowers.*—That difference in relative length or height of stamens and style, reciprocally, which in Torrey and Gray's Flora of North America, was very long ago designated by the term *diœcio-dimorphism*, Mr. Darwin—who detected and has made much of the meaning of the arrangement—called simply *dimorphism.* Besides these *dimorphic*, he also brought to view *trimorphic* flowers. The first name is too long for use, and carries with it some ambiguity, since it may imply a separation as well as a diversification of the sexes. Mr. Darwin's term has the disadvantage of not indicating what parts of the blossom are *dimorphic* (hermaphrodite flowers may be dimorphous in the perigonium), and a more generic name is now required, on account of *trimorphic*, etc. This has been supplied by Hildebrand, in Germany, who has introduced the term *heterostyled* and the counterpart *homostyled.* These are not particularly happy appellations; for the difference is in the stamens as well as in the pistil, and in the latter is not always restricted to the style. Well-established terms ought not to be superseded on the ground of mere improvement; but those which have not yet taken root sometimes may be. Following the analogy of *perigonium* or *perigone*, I propose the more exactly expressive term of *heterogone* (or *heterogonous*) for these flowers, such as those of *Primula*, *Houstonia*, *Lythrum*, etc. The counterpart, *homogone* (or *homogonous*) would designate the absence of this kind of differentiation. These terms, either in Latin or English

form, would work well in generic or specific characters, and have the advantage of etymological correctness. A. G.

3. *Geographical Statistics of the European Flora.*—In a paper contributed in 1874 to the Transactions of the Historic Society of Lancashire and Cheshire, Mr. Thomas Comber discussed the geographical statistics of the British flora. In another paper, read March, 1875, these enquiries are extended to the rest of the flora of Europe; and the dispersion considered with regard to latitude, station, habit of growth, character of flower, nature of fruit, seed, etc. Contrary to the common idea, the European maritime phænogamous plants appear to be less widely dispersed, on an average, than the non-maritime. Trees and shrubs range rather more widely than herbaceous plants over land, less so over sea. Plants with creeping rootstocks or stolons are much more widely dispersed than those without them. The distribution of annuals, especially of the warmer temperate species, exceeds that of perennial herbs. Endogens are more widely spread than Exogens, Apetalæ than Polypetalæ, and still more than Gamopetalæ; plants with inferior ovary are more limited than those with superior ovary; that is, the lower and less specialized in structure are more widely distributed than the higher or more specialized. That the inconspicuously colored surpass in range those with brightly colored and conspicuous flowers, may be regarded as another illustration of the same rule. The Cryptogams, of course, have much the widest range. Plants with fleshy fruit considerably surpass those with dry fruit in area of distribution, in the ratio of about 5 to 3. Of the dry fruits, the indehiscent belong to plants with a somewhat higher average of distribution. The curious conclusion, formerly reached from various data, is confirmed by the statistics of the European flora, namely, that *Compositæ* with pappus, on the average, are less widely distributed than those without; and generally, that plants with special adaptations for dispersion of fruit or seeds, are rather less widely dispersed than those which have no such special appliances; excepting, however, the coma of seeds. This, as De Candolle concludes, and Mr. Comber confirms, is accompanied by a high degree of dispersion. Much of this probably comes from the large number of *Salices* in the European flora; these being woody plants of comparatively low organization, and largely boreal. We doubt if this rule holds with *Asclepiadeæ*—the most comose-seeded of the higher orders. The species of *Asclepias* in North America are not remarkable for wide range. Although number of seeds might be supposed to give advantage, yet, on the whole, the European plants with solitary seeds have somewhat wider range than those with two or more seeds in each cell. Plants with albuminous seeds somewhat surpass in range the exalbuminous. This is remarkable in view of the fact that seeds of longest known vitality and which best endure exposure to sea water, are mainly exalbuminous or nearly so. Large genera have somewhat higher dispersion than small ones; and variable species, than those not particularly variable. The laws that govern the distribution of plants are complex and recondite. A. G.

4. *The Wild Flowers of America.* Illustrations by ISAAC SPRAGUE. Text by GEORGE L. GOODALE, M.D., Assistant Professor of Vegetable Physiology and Instructor of Botany in Harvard University. Part I. Boston: (Houghton & Co.) Dec. 1876. pp. 16, tab. 1–4, imp. 4to.—It is proposed to published this work in quarterly parts or numbers, and in it "to present illustrations and descriptions of all the more attractive flowering plants of America,"—meaning, no doubt, the United States, and the Atlantic portion of them, without excluding, perhaps, the Western and even the Pacific States as the work goes on. It is a large undertaking, even under the most restricted view. The want has been felt, and various futile attempts have been made to supply it. They have speedily come to nought, most of them deservedly, the few worth having because they would not pay. The only work of the kind we can now call to mind which gave fairly good figures of our wild flowers, and which was carried beyond a single part or volume, was by the late Dr. W. P. C. Barton. This was upon a plan not unlike that of the present work, perhaps equally expensive, for the figures were hand-colored, but far less sumptuous, and the figures—though really good—by no means so admirable as those by Mr. Sprague, who is almost unrivaled as a botanical draughtsman. These figures are not in the style of the North American Genera Illustrated, in which Mr. Sprague's talent in this line was first made known. The plates of that work were addressed to botanists only, are uncolored outlines, mainly valuable for their dissections and other details. These are imperial quarto plates, representing the flowers and as much of the herbage as is needed to give their part and bearing, in their natural colors, reproduced from the artist's paintings by the chromo-lithographic process. The undertaking was probably suggested by the success of this kind of work by the same artist in the colored plates of Mr. Emerson's Trees and Shrubs of Massachusetts, to which we called attention a year ago. The present work therefore addresses itself to amateurs as well as to botanists, to all lovers of flowers and admirers of beautiful works of art. From all these evidently it must have a large patronage if it is to prosper and continue. Nothing upon such a scale of excellence has ever been attempted in this country before. The plates are simply exquisite; in the typography the Riverside Press has done its best; and the letterpress not only describes the flowers represented clearly and popularly, but expatiates upon their arrangements for insect-aid in fertilization—the novel and attractive topic of the day—and adds other curious lore.

The first plate charmingly represents our wild Columbine (*Aquilegia Canadensis*); the second, our wild Cranesbill (*Geranium maculatum*); the third, ~~Man~~y-leaved Aster (*Aster undulatus*); the fourth, both the Yellow Gerardia (*G. flava*) and the commoner slender purple species, *G. tenuifolia*. (We take blame to ourselves for having given currency to "False Foxglove" as a popular name for the large yellow-flowered species of *Gerardia*. Gerardia makes a good popular name, and would soon become as familiar as *Magnolia* or even *Lobelia.*) "The great expense attending the work requires that the price per part shall be $5.00," say the publishers. We admire their courage in the enterprise, and in aiming at the highest attainable excellence. There are indications that their laudable endeavors will be responded to, and that the time has at length arrived when a popular work of this kind and in this style—so creditable to all concerned in it—may be appreciated and sustained. A. G.

5. *Report upon Geographical and Geological Explorations and Surveys, west of the One-hundredth Meridian*, in charge of First Lieutenant GEO. M. WHEELER, under the direction of Brigadier General A. A. Humphreys, Chief of Engineers, U. S. A. Vol. V. Zoology. Washington: Government Printing Office. 4to, 1019 pp., with 45 plates.—This large and valuable volume is handsomely executed, and is in every way creditable to the officers under whose direction it has been prepared, and to the several naturalists who have contributed reports to it. The plates are well executed, and several are colored (chromolithographs.) Although this volume is dated 1875, and was doubtless then printed, it appears not to have been actually published until the latter part of the summer or early in the autumn of 1876. It includes the following reports:

Introductory Letter, by H. C. Yarrow, M.D., surgeon and naturalist to the expedition; Notes upon Geographical Distribution and Variation, by Dr. Yarrow; Report upon the collections of Mammals, by Dr. Elliott Coues and Dr. Yarrow; Report upon the Ornithological Collections, by H. W. Henshaw; Report upon the collections of Batrachians and Reptiles, by Dr. H. C. Yarrow; Synopsis of the Reptiles and Batrachians of Arizona, with critical and field notes and an extensive synonymy, by Dr. Coues; Report upon the collections of Fishes, by Prof. E. D. Cope and Dr. Yarrow; Report upon the Hymenoptera, by E. T. Cresson, with List of Formicidæ, by Edward Norton; Reports upon the Diurnal Lepidoptera, by T. L. Mead and W. H. Edwards; Report upon new species of Zygænidæ and Bombycidæ, by R. H. Stretch; Report on Diptera, by C. K. Osten-Sacken; Report upon the Coleoptera, by Henry Ulke; Report upon the Hemiptera, by P. R. Uhler; Report upon the Orthoptera, by Prof. Cyrus Thomas; Report on the Neuroptera and Pseudo-neuroptera, by H. A. Hagen; Report upon the terrestrial and fluviatile Mollusca, by Dr. Yarrow; Report upon the fresh-water Leeches, by A. E. Verrill. The plates illustrate rare or novel species and varieties of birds, reptiles, fishes, and insects. A. E. V.

IV. ASTRONOMY.

1. *The secular change of Magnetic Declination in the United States, and other parts of North America: New discussion by* CHARLES A. SCHOTT, Assistant U. S. C. S.—This is an extension of Mr. Schott's paper in the Coast Survey Report of 1859, and forms App. No. 8 of the Report for 1874. Forty-three sta-

tions are represented in the discussion, and over 400 observations. Formulæ are given for each station, with decennial tables computed therefrom. Mr. Schott says:

"A cursory examination of the column containing the epochs of greatest *easterly* excursion, the *deflecting* force producing the secular change attaining then an easterly maximum, shows that the needle became stationary in direction, and then reversed its secular motion, in the New England States toward the end of the past century, in the Atlantic coast States to the west and south early in the present, and in Mexico about the close of the first third of the present century. In California, Oregon and Washington Territory, it has not yet reached this condition. We thus have the following epochs for comparison: Halifax, about 1711; Portland, Portsmouth, Newburyport, Salem, Boston, Cambridge, Nantucket and Providence, about 1779; Hartford, New Haven, New York, Hatborough, Philadelphia, Washington and Cape Henry, about 1800; Charleston, Savannah, Key West and Havana, about 1800; New Orleans, about 1831; Vera Cruz, Mexico, Acapulco and San Blas, about 1837; San Diego, Monterey and San Francisco, expected about 1907 (yet very uncertain.)

We are thus directed to the extreme northeastern States for probable indications of what may be expected to follow on the seaboard in more southern and western States. Respecting the secular movement of the needle, apparently a little more than a century passed before the influence which produced the turning of the north end of the needle westward in Maine (increasing there the western declination), was felt in Lower California (diminishing there the eastern declination). In California, Oregon, and Washington Territory, the eastern declination is at present still *increasing*, but with a losing rate. By the time the western elongation of the secular change is reached in Maine, we may expect to see the needle in the *opposite* phase, or at its eastern elongation in California. We cannot as yet follow this influence directly over the interior of the United States for want of early observations; the westernmost interior stations for which an epoch could be made out were Buffalo, Erie, Cleveland and Detroit; these give the average turning epoch 1794. It may be quite practicable hereafter to trace out curves uniting all stations where the needle was stationary at a given epoch, and again at other epochs for regular intervals of time, say of ten or twenty-five years.

Returning to the first table, the constant in each formula would represent the normal direction of the needle about which the motion constituting the secular change would be performed in an average cycle of about two hundred and seventy years, and with extreme deflections on either side of it equal to the coefficient of the periodic term, all under the *supposition* that the law of the secular movement was truly expressed. It is no doubt much more complex, and besides may fail at any time; yet, as far as our present experience reaches, and within the interval when the first reliable observations were made to the present time, it is found trustworthy."

2. *Investigation of Corrections to Hansen's Tables of the Moon;* by S. NEWCOMB.—This memoir forms Part III of papers published by the Commission on the Transit of Venus. For determining the longitude of the Transit Stations from moon occultations it became necessary to determine the errors in the tables of the moon which 13 years' observations and the discussions of earlier data develop. It was already known that an unexplained correction to the moon's mean motion must be applied, that now amounts to about $10''$. In addition to this and to several other corrections, Prof. Newcomb finds an empirical term necessary to satisfy observations, the form of which is,

$$1'',50 \text{ sin. } [g+21^\circ,6(Y-1865{\cdot}1)],$$

where g is the mean anomaly, and Y the date in years. This term is not yet explained in the theory of the moon.

3. *Knobel's Reference Catalogue of Astronomical Papers and Researches.*—We have received advance sheets of the Monthly Notices of the Royal Astronomical Society for November, 1876, which contains an important bibliographical paper by E. B. KNOBEL, F.R.A.S., with the title above. The author has selected various subjects of Stellar Astronomy, and has made nearly exhaustive indices of the various memoirs and papers relating to these published in the many astronomical and scientific periodicals and in separate treatises. The subjects chosen are: (1.) Double Stars, and the theory of Binary Systems. (2.) Variable Stars. (3.) Red Stars. (4.) Nebulæ and Clusters. (5.) Stellar proper motions. (6.) Parallax and Distance of Stars. (7.) Star Spectra. These are thoroughly and carefully indexed, Double Stars alone having over 700 references, and the rest being equally full. There are about 3,000 references in the list, and a careful examination of one section by the writer has proved its accuracy and its completeness. E. S. H.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Notes on Assaying and Assay-Schemes;* by PIERRE DE PEYSTER RICKETTS, E.M., Ph.D., etc. 172 pp. 8vo. New York. 1876.—Dr. Ricketts, Instructor in Charge of the Assay Laboratory of the School of Mines, Columbia College, has embodied in this work the system of assaying practiced in the school which has been developed under Dr. Chandler and his assistants. Every such treatise is sure to add something to the common stock in its department. The notes are systematic, and the assay-schemes are clearly presented and specific. B. S.

2. *Alcoholic Strength of Australian Wines.*—From the report of a commission appointed by the Governor to inquire into the alcoholic strength of South Australian wines, and printed by authority of the House of Assembly (July, 1874) at Adelaide, it appears that the amount of glucose in the mature grapes of that province ranges from 25 to 30 per cent, and produces in the wine an alcoholic strength of from 28 to 40 per cent of proof spirit.

One sample of must, prepared March 24, 1874, from the press of Hon. Samuel Davenport, at Beaumont, gave a specific gravity at 70° F. of 1·1425, which corresponds to 28·409 grams per gallon of glucose, and 20·743 per cent of absolute alcohol, or 44·522 of proof-spirit by measure.

The average of 17 samples of must, pressed from the grapes by the two analysts, Messrs. Copins and Thomas, to avoid all chance of falsification in the hands of the vintner, gave for the specific gravity 1·1179: grape-sugar, 27·259=proof-spirit, 28·419 per cent. The maximum of sugar and proof-spirit in the 17 samples examined by these two chemists was found in the juice of the Frontignan grape grown by Mr. Gillard, at Norwood, namely—sugar, 32·165; proof-spirit, 33·505.

Mr. Francis, one of the analysts, says in his report, "the natural grape juices of this colony are capable of producing very strong wines, which are more likely to exceed 26 per cent of proof-spirit than otherwise, and that the fruit contains all the elements to set up and complete fermentation to the full conversion of the sugar into alcohol without acetification."

From the colonies of Victoria and New South Wales we have a report on the alcoholic strength of 200 samples of wine, of which 38 were from the latter colony, in Albury district; 101 from Murray district, in Victoria, and the remainder from eight other wine districts of the same colony. Messrs. Moody and Heath, government inspectors of distilleries, made the determinations. They show, for New South Wales and the Murray district, a range of proof-spirit from a minimum of 20 per cent to a maximum of 34, the greater number ranging about 28.

The grapes cultivated are exclusively of European origin. The soil and climate are wonderfully well adapted to the growth of abundant fruit; but as yet the qualities of bouquet and flavor, admired in the best European wines, are feebly and often not at all developed in those of Australia made from the same grapes. Nor is the *gôut de terre*—the result of a too rank soil and growth—wanting in the Australian wines. In this respect and in intoxicating power they much resemble the wines of California. B. S.

OBITUARY.

F. B. MEEK, the author of various elaborate works and memoirs on American Paleontology, died on the 22nd of December. An obituary notice is deferred to the following number.

DAVID FORBES, a learned geologist, Foreign Secretary of the Iron and Steel Institute, one of the Secretaries of the Geological Society of London, a Fellow of the Chemical and also of the Royal Society, died on the 5th of December, aged forty-eight years. He was a great traveller and resided for a while in Bolivia and Peru making researches in its mines and geology, which he afterward published.

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[THIRD SERIES.]

ART. VIII.—*Astronomical Observations on the Atmosphere of the Rocky Mountains, made at elevations of from* 4,500 *to* 11,000 *feet, in Utah and Wyoming Territories and Colorado;* by HENRY DRAPER, M.D., Professor of Analytical Chemistry and Physiology in the University of New York.

ANYONE who observes with a large telescope soon becomes aware of the great obstacle atmospheric undulation offers to the pursuit of astronomy, particularly in the application of photography and the spectroscope. During two years when I photographed the Moon on every moonlight night at my observatory* there were only three occasions on which the air was still enough to give good results, and even then there was unsteadiness. Out of 1,500 lunar negatives only one or two were really fine pictures. A letter which the late Mr. Bond wrote to me states that in seventeen years he had never met with a perfectly faultless night at the Cambridge Observatory.

Such facts naturally cause astronomers to consider whether it is not possible to diminish atmospheric disturbances, and have led to the celebrated expeditions of Professor Piazzi Smyth to the Peak of Teneriffe and Mr. Lassell to Malta. Theoretically, it would seem that the only complete solution is to ascend high mountain ranges or isolated peaks, and leave as much as possible of the air below the telescope.

Having had occasion during the months of August and September, 1876, to go on a hunting trip with two distinguished officers of the United States Army into the Rocky Mountains and Wahsatch range, I thought it desirable to carry a telescope with a view of ascertaining whether there would be sufficient inducement to return with my twelve-inch achromatic or twenty-eight-inch reflector and make a prolonged stay. The experience which Professor Young had had at Sherman station, on the Union Pacific Railroad, left the question open, for he suffered from an unusually cloudy season, and, while he obtained very gratifying results, he seems on the whole to have been disappointed with the character of the atmosphere.

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* Professor Henry Draper's Observatory is at Hastings-on-Hudson, near New York; latitude 40° 59′ 25″; longitude 73° 52′ 25″; elevation above the sea, 225 feet.

As the region into which the party proposed to go was difficult of access and entirely without roads and much of the traveling was to be on horseback, through fallen timber and up precipitous places, it was not feasible to take an instrument of any great size. I therefore contented myself with a small achromatic of unusual excellence. Though of only one and one-quarter inches aperture, it bears a power of upwards of sixty completely, and I think would carry one hundred. It was provided with a short brass tripod, holding an altitude and azimuth movement, giving both steadiness and smoothness of action. The eye-piece was capable of adjustment by a rack and pinion, and the object-glass was so arranged in its cell as to be free from injurious compression. This little lens stands the severe tests invented by Foucault, and in spite of its size is capable of doing good work.

In such observations on the atmosphere as those proposed during this trip, it is obvious that there are mainly two points to be considered: first, freedom from tremor, and second, transparency. A station which combines both is most desirable, but a marked predominance of steadiness gives special advantages for celestial photography while increase of transparency even if accompained by unsteadiness is of value in eye observations. I had been led to suppose, from conversations with Government officers and persons connected with the geological and geographical surveys of the Territories, that the Wahsatch range, which is intermediate between the Sierra Nevada on the west and the true Rocky Mountains on the east, would offer the greatest advantages. This supposition turned out to be altogether incorrect, though it might have been argued that a high range flanked at a distance on either side by other higher ranges should have given the maximum chance for cloudless and still skies.

We first went to Salt Lake City, which, according to the Casella aneroid I carried, is at an elevation of 4,650 feet above the sea. It lies at the foot of the Wahsatch range. At eleven o'clock on the evening of arrival, August 25th, I took some observations from the hotel, after carefully centering the object-glass. Saturn looked about the same as on an ordinary night at my observatory. Capella, which was just clear of the house-tops across the street, twinkled as badly both to the naked eye and in the telescope as I have ever seen it at the sea-level. Lieutenant Warren, of Camp Douglas (a military post near the city) said there had been a heavy rain the week previous and the air was more moist than usual. I had noticed that the sun set among just such a bank of clouds as we are accustomed to see in New York. I was somewhat prepared for a tremulous condition in these high regions, because, the preceding night having stopped for a few minutes at Fort Steele, on the Union Pacific Railroad, I perceived that Antares twinkled very much though we were nearly 7,000 feet above the sea.

However, in order to make a thorough trial it seemed best to ascend one of the high peaks of the Wahsatch, and accordingly the Red Butte was selected. The officers at Camp Douglas facilitated the trip in every way, furnishing horses and a guide, and the surgeon of the Post, Dr. Smart, who is an able and scientific man, accompanied me. The peak proved to be 7,350 feet high. Though it was quite clear when we started, clouds gathered in every direction as the sun went down, and at night-fall the sky was entirely overcast. Moreover, the wind blew so strongly that it was necessary to retire over the brow of the mountain, and eventually we returned to Camp Douglas. At this point, 5,250 feet above the sea and about 600 feet higher than Salt Lake City, the telescope was set up to take advantage of some breaks in the clouds, through which the Moon, Antares, ζ Ursæ Majoris and Jupiter appeared. With a power of only twenty the twinkling was surprisingly great; I do not remember ever to have seen it worse with my large instruments.

These results led to an examination into the meteorology of Salt Lake City, so as to find out the rainfall and its distribution and the percentage of cloudy days. Dr. Smart had the following copy of the post records made for me:

TABLE I.—*Rainfall and other Cloudy Days at Salt Lake City.*

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	Rain fall & melted Snow.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.
1872	1·30	..	2·60	19	1·20	..	2·04	..	2·34	16	·58	11
1873	2·18	23	1·89	19	·90	11	2·00	10	4·10	16	·24	5
1874	1·28	18	1·03	17	2·87	21	·77	16	2·89	16	·72	18
1875	2·21	31	·80	28	2·37	31	1·05	23	3·29	4	1·10	7
1876	1·22	27	·90	23	4·00	28	1·79	17	4·04	19	·14	7

TABLE I—continued.

	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	R in fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.
1872	·02	10	·72	16	·94	9	1·44	13	·66	16	2·26	15
1873	·12	7	·94	14	·42	6	·84	13	·38	10	1·20	24
1874	2·12	10	2·11	9	·39	6	1·89	27	2·26	26	1·06	27
1875	·64	14	0	6	1·15	18	1·48	18	4·54	30	2·78	31
1876	1·08	6										

From Table I, it appears that the average annual rainfall for the past five years is $18\frac{40}{100}$ inches, distributed as shown in Table II. There is no perfectly dry month, the nearest approach being during the summer. The cloudy days are 194 per annum, the disposition being similar to the rainfall.

TABLE II.

January,	1·64 inches of rain.	25 cloudy days.
February,	1·44 "	21 "
March,	2·27 "	23 "
April,	1·53 "	16 "
May,	3·33 "	14 "
June,	·56 "	9 "
July,	·80 "	9 "
August,	·94 "	11 "
September,	·70 "	8 "
October,	1·41 "	18 "
November,	1·96 "	20 "
December,	1·82 "	24 "

A former pupil of mine, and graduate of the University, Dr. Benedict, informed me that the Mormons believed the rainfall had much increased since their community had settled in Utah, and this seems to be borne out by the statement that whereas formerly three gallons of Salt Lake water produced on evaporation one gallon of salt it now takes four gallons to produce the same quantity.

On the whole it is doubtful whether there would be enough advantage in bringing a large telescope to this region to make it worth while to encounter the labor and expense.

On August 30th, having taken an escort we moved south from Fort Steele, latitude 41° 48′, longitude 107° 09′, along the north fork of the Platte River into the main range of the Rocky Mountains. During the fifteen days' expedition there were only two nights on which we saw clouds enough to prevent astronomical working, and only one thunder storm of any moment took place in our immediate vicinity; about one-quarter of an inch of rain fell. The sky was rarely perfectly free from clouds and many local thunder storms occurred about the higher peaks, but they seldom extended to the plateaus below.

September 1st and 2d our camp was 8900 feet above the sea in the vicinity of mountains rising 10,000 and 11,000 feet. These peaks seemed to be nearer than they really were, for the transparency of the air causes estimates of distance to be deceptive. From the top of one I subsequently saw the Seminole mountain which was 150 miles distant; it did not appear to be 50 miles away. The night of Sept. 1st was quite clear, with very little cloud, and the atmosphere remarkably tranquil. Antares, when near setting, hardly twinkled at all, and Arcturus in the telescope exhibited four diffraction rings unbroken by flickering. The central disc was as hard and sharply defined as the pinhole in the lamp screen I am accustomed to use in testing specula and lenses. I looked for the companion of Polaris, but partly on account of the nearly full Moon, and partly from the thickness of the diffraction rings, I could not be sure of it. The Moon was perfectly steady; with a power of 60 there was no trace of twinkling at the terminator. I tried to see Titan, the largest satellite of Saturn, but did not succeed. At the time it was not certain whether this failure was due to the position of Titan with relation to Saturn, or whether it arose from the blinding effulgence of the Moon. Capella was perfectly steady though there was a slow change of color from bluish to reddish occupying about a second.

The succeeding night at nine o'clock, though the sky was mostly covered with cumulus clouds in motion southward, I was surprised to find the terminator of the Moon absolutely free from twinkling, and Arcturus down among the tops of the dead aspen trees as steady as possible. The four diffraction rings round the central disc were not perfectly circular, but that was the fault of the lens. Every defect of centering or of surface, and any vein in the glass comes out even more clearly than in the workshop examinations, because while the air is as steady the light is far more intense.

I am certain if a large telescope could be brought here and maintained against the furious winds great results might be attained if there is much of this weather. But this particular place is difficult of access and possibly no better than other situations on the line of the railroad. The sky is not as black as I had expected; it is rather of a light blue, though the full Moon makes much difference.

On several other nights in both lower and higher places I made observations but never saw the combination of steadiness and transparency again. On the plateaus at the foot of the mountains and away from the groves of aspen trees and pines the sun sends down scorching rays all day long on the alkali plains where only sage plants are sparsely scattered, and even on horseback one can see the heated waves rising from the ground. The air is far from being moist for the lips are apt to crack and bleed, and the mucous membrane of the nose is parched. When the sun sets the ground radiates rapidly, and we frequently had by morning one-quarter of an inch of ice in our vessels of water standing outside the tents. These plateaus are on an average about 7250 feet above the sea. The mere fact of broken ground and wooded surroundings does not however suffice to produce, even at this season, a tranquil air, for when we rode over the Rocky Mountains along the margin of perpetual snow to the headwaters of Snake River, and camped at Trout Lake nearly 10,000 feet high, though the air was exceedingly transparent it was very unsteady. I rose at four A. M. to see Venus, and her splendor was so great that it led to a most delusive estimate of her apparent size. Occasionally during clear frosty weather in midwinter a night of similar characteristics is seen at my observatory. On such an occasion I obtained at the principal focus of the 15½-inch reflector a photograph of the Moon near her third quarter in less than a second.

The officers of Fort Steele and the guides say it would be impossible to do any astronomical work in this region from the middle of October till the middle of May, that is, for seven months. The fierce winds, heavy falls of snow and intense cold would be unbearable. Even in the beginning of September we needed large camp fires in the morning and evening. Our camp at Trout Lake could only be reached for six weeks in summer on account of the depth of snow in the fallen timber.

On the whole it may be remarked of this mountain region that the astronomical condition, particularly for photographic researches, is unpromising. In only one place were steadiness and transparency combined, and only two nights out of fifteen at the best season of the year were exceptionally fine. The transparency was almost always much more marked than at the sea level, but the tremulousness was as great or even greater than near New York. It is certain that during more than half the year no work of a delicate character could be done. At the end of August in sheltered positions, and in good tents, we slept under half a dozen thicknesses of blanket and only partially undressed. Such a degree of cold distracts the mind and numbs the body. Apparently, therefore, judging from present information, it would not be judicious to move a large telescope and physical observatory into these mountains with the hope of doing continuous work under the most favorable circumstances.

ART. IX.—*Photographs of the Spectra of Venus and α Lyræ.*
Note by Prof. HENRY DRAPER, M.D.*

SINCE the spring of 1872 I have been making photographs of the spectra of the stars, planets and Moon, and particularly, among the stars, of α Lyræ and α Aquilæ with my 28-inch reflector and 12-inch refractor. In the photograph of α Lyræ, bands or broad lines are visible in the violet and ultra-violet region unlike anything in the solar spectrum. The research is difficult and consumes time, because long exposures are necessary to impress the sensitive plate, and the atmosphere is rarely in the best condition. The image of a star or planet must be kept motionless for from ten to twenty minutes, and hence the driving clock of the telescope is severely taxed.

During last summer I obtained good results, and in October took photographs of the spectrum of Venus, which show a large number of lines. I am now studying these pictures, and have submitted them to the inspection of several of my scientific friends, among others Professors Barker, Langley, Morton aud Silliman. There seems to be in the case of Venus a weakening of the spectrum toward H and above that line, of the same character as that I have photographically observed to take place in the spectrum of the Sun near sunset.

New York, December, 1876.

ART. X.—*On Dinitroparadibrombenzols and their Derivatives;*
by Dr. PETER TOWNSEND AUSTEN. Second Paper.

THE separation of the three isomeric dinitroparadibrombenzols I have already described in a previous paper.†

The residue from the separation of the α- and β-isomers consisted, for the most part, of β-dinitroparadibrombenzols, which forms the chief product of the nitrition. These residues were collected and, after several crystallizations from carbon disulphide, were recrystallized from glacial acetic acid. After six crystallizations, the fusing point remained constant.

Betadinitroparadibrombenzol.

The betadinitroparadibrombenzol crystallizes from its solution in carbon disulphide in thick white pointed and peculiarly bent needles. It is very easily soluble in the usual solvents, especially in glacial acetic acid, carbon disulphide, acetic ether,* alcohol, etc.

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* This article was printed on the third page of the cover of the January number, and is here reproduced without change.—EDS.

† This Journal, vol. xii, 118, 1876.

It fuses at 99°–100°† to a yellowish liquid. 0·2940 grms of substance gave 0·0330 grms. of H^2O, and 0·2418 grms. of CO^2.

Calculated for $C^6H^2(NO^2)^2Br^2$.	Found.‡
C=22·08	22·43
H= 0·61	1·24

The compound is somewhat volatile. Inspiration of its vapors occasions an intense inflammation of the mucous membranes. An alcoholic solution, when brought upon the skin, excites itching, smarting, and inflammation accompanied by subsequent peeling off of the skin. A minute quantity brought in contact with the eye causes a sharp pain lasting several days. On the more sensitive skin of the face it gives rise to a smart which, after it has attained a maximum, suddenly vanishes. It is hence a powerful excitant.

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* It is very striking that nearly all substances which are soluble in glacial acetic acid, are also soluble in acetic ether.

† In a preliminary notice I gave the fusing point as 120°. The substance was not quite free from the isomeric compounds. The separation of the last traces of the isomers is exceedingly difficult. The greatest care is also necessary in the determinations of the fusing points, for the substance which fused at 130° retained the same fusing point even after four crystallizations from glacial acetic acid. A single crystallization from alcohol, however, sufficed to prove it a mixture. In a similar manner a mixture of substances, with which I have recently been working, retained an exact fusing point of 195° during seven crystallizations from glacial acetic acid, while two crystallizations from alcohol proved that two-thirds of the mixture consisted of a substance fusing at 136°.

‡ I have rarely analyzed a substance which was so refractory during combustion as this betadinitroparadibrombenzol. All attempts at burning it with copper oxide or lead chromate failed owing to the sublimation of the substance to the upper part of the tube, from which the highest attainable heat of the combustion furnace was inadequate to dislodge it. In making the combustions of this compound, as well as of many other substances encountered in this investigation, I have used a variation of the ordinary method of combustion, which has of late found an extended application in the analysis of refractory organic substances. It was suggested to me by Mr. Bauermeister of the Berlin University laboratory. I have employed it, in most cases, in preference to combustion in a stream of oxygen gas. Copper oxide, in the form of spiculæ (length about 10mm., diameter about 1 to 2mm.) having been first introduced into the tube, the substance is well mixed in a mortar with lead chromate to which its equal volume of the copper oxide is afterwards added, and the whole again well mixed. After introducing the mixture into the tube, the mortar is well washed out with a mixture of oxide and chromate (equal parts) and the washings added to the contents of the tube. The tube is then filled up with chromate, leaving room for a copper spiral, in case the substance to be analyzed contains nitrogen, and rapped on the pointed end so that the contents may compact. This having been accomplished, the tube is rapped longitudinally. The heavy pulverulent lead chromate sinks to the bottom leaving the channel filled with a net-work of copper spiculæ. The gases have to pass through this net-work and are hence exposed to a very great oxidizing surface. Loss by sublimation is entirely avoided, since the substance must necessarily be deposited on the spiculæ and by them be completely oxidized. In case the compound contains haloid elements, about two inches of the lead chromate nearest the cork end of the tube must be kept just off the red heat ("black") so as to prevent any of the haloid copper compounds, which may be formed, from passing into the potash bulbs.

Betadinitroparabromaniline.

By heating the betadinitroparadibrombenzol with alcoholic ammonia for eight hours in a closed tube at 100°, I obtained a deep red solution, from which a large mass of red scales separated on cooling. The solution was poured into cold water, and the resulting yellow precipitate dissolved in boiling absolute alcohol which contained animal charcoal, filtered, and allowed to stand. The pure substance obtained in this manner formed orange-red scales fusing at 160°.*

0·3010 grms. of substance gave 0·0506 grms. of H^2O and 0·3044 grms. of CO^2.

0·24 grms., after the method of Carius, gave 0·148 grms. of AgBr and 0·0027 grms. of Ag.

Calculated for $C^6H^2(NO^2)^2NH^2Br$.	Found. I.	Found. II.
C = 27·48	27·58	.....
H = 1·52	1·86	.....
Br = 30·53	....	30·90

The substance is easily soluble in boiling alcohol and glacial acetic acid. It is almost insoluble in water, and entirely so in carbon disulphide.

It is not acted upon by boiling amyl nitrite, although in a closed tube at 100° the substances react. No defined product was obtained, which, however, was more probably owing to the small amount of substance used than to the absence of a dinitrobrombenzol.

Strong alcoholic ammonia remained at 200° without action upon it. This, however, was not surprising, since, according to Meyer and Wurster,† only one bromine atom of the mononitroparadibrombenzol can be substituted by direct action of ammonia. A somewhat similar case is recorded by Armstrong.‡ He found that the chlorine atom of dinitrochlorphenol was not affected by ammonia. The weakening action of the nitro-groups may, perhaps, here be overcome by the formation of the ammonium salt.

When boiled with alcoholic potash the substance evolves ammonia, but the nitro-groups appear to be affected, and a general decomposition is the result.

Betadinitroparabromanilidobenzol.

On treating the betadinitroparadibrombenzol with aniline, the mass assumed a fine red color. On heating a violent reaction ensued, and the mixture boiled of itself. The solution was allowed to cool, and then treated with dilute chlorhydric acid. An oil separated and gradually solidified. The dark violet mass was several times well washed with water, and then dissolved in boiling absolute alcohol containing animal charcoal, filtered, and allowed to crystallize. The substance forms superb orange-red fine hairy needles fusing at 120°. They are soluble in boiling glacial acetic acid and in alcohol.

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* It is worthy of notice that the fusing point of this compound (160°) is nearly the same as that of the alphadinitroparadibrombenzol (159°).

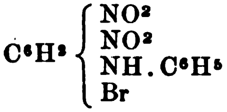
† Ber. d. d. chem. Ges., v, 632.

‡ Chem. Soc. J., (2), x, 12.

0·2885 grms. of substance gave 0·0684 grms. of H^2O and 0·4444 grms. of CO^2.

0·1685 grms. after the method of Carius gave 0·0910 grms. of AgBr and 0·0016 grms. of Ag.

Calculated from the formula—



$$C^6H^2\left\{\begin{array}{l}NO^2\\NO^2\\NH.C^6H^5\\Br\end{array}\right.$$

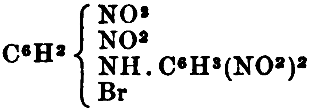
Theory.	Found. I.	Found. II.
C =42·60	42·64	....
H = 2·36	2·67	....
Br=23·66	....	23·56

Betadinitroparabromdinitroanilidobenzol.

The preceding compound was added in small portions to fuming nitric acid at a temperature of +12°. It dissolved quickly with a weak action, the color of the solution becoming darker. The resulting solution was poured into cold water, and the bright yellow powder which separated was crystallized from boiling glacial acetic acid. The substance forms small brownish yellow scales, which fuse at 167·5°.

0·2057 grms. of substance after the method of Carius gave 0·0552 grms. of AgBr and 0·0035 grms. of Ag.

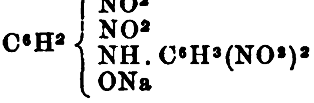
The formula—



$$C^6H^2\left\{\begin{array}{l}NO^2\\NO^2\\NH.C^6H^3(NO^2)^2\\Br\end{array}\right.$$

requires 18·69 Br; 18·81 was found.

The compound is easily soluble in boiling glacial acetic acid, but with difficulty in alcohol. If it be warmed with a solution of sodic hydrate, it forms immediately a deep blood red solution, from which, after a few minutes have elapsed, the separation of glittering red and green dichroic needles takes place. This compound I take to be a sodium betadinitroparadinitroanilidophenylate—



$$C^6H^2\left\{\begin{array}{l}NO^2\\NO^2\\NH.C^6H^3(NO^2)^2\\ONa\end{array}\right.$$

University Laboratory of Berlin, July 15, 1876.

ART. XI.—*On some Points in connection with Vegetation;* by Dr. J. H. GILBERT.

[Continued from page 32.]

Amount of nitrogen assimilated by plants.—Let us now recur to the question of the various amounts of nitrogen assimilated over a given area by plants of different natural orders, and call attention to the facts bearing upon the point which these experiments on the mixed herbage of grass land have supplied.

TABLE IV.—*Yield of Nitrogen in the Mixed Herbage of Permanent Grass land at Rothamsted.*

Plots.	Conditions of Manuring.	Average Produce per acre per annum, 20 years, 1856–1875, according to Mean per cent at 6 periods 1862, '67, '71, '72, '74, '75.			Average nitrogen per Acre per annum.		
		Gramineæ.	Leguminosæ.	Other Orders.	10 years 1856–1865	10 years 1866–1875	20 years 1856–1875
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3	Unmanured	1635	219	529	35·1	30·9	33·0
4-1	Superphosphate*	1671	149	673	35·7	31·5	33·6
8	Complex Min. Manure.†	2442	296	639	54·4	38·1	46·3
7	Complex Min. Manure.‡	2579	806	573	55·2	56·0	55·6

In Table IV. is shown the average produce (in the condition of hay) in lbs., per acre, per annum, over twenty years, of herbage of the gramineous family, of herbage of the leguminous family, and of herbage of other orders, calculated according to the mean percentage of each of these, determined in separations at six periods, namely, in 1862, 1867, 1871, 1872, 1874, and 1875, in samples of the produce of four of the plots which have received no nitrogenous manure from the commencement; and there is also given, by the side of these results, the average annual yield of nitrogen per acre over the first ten, the second ten, and the total period of twenty years, in each case.

The quantities of nitrogen yielded are calculated from the results of actual determinations of the nitrogen in the mixed produce of the respective plots; but the estimates of the quantity of the produce referable to the different Natural Orders must be taken as only giving a general indication or an approximation to the truth; for, while the amount of the total mixed produce is the average of that of the twenty years, the amount of it referred to the different orders is calculated upon their percentage determined in six years only, four of which are among the last five, and the fluctuation according to season is in some cases very considerable, while in others there is a progression in the changes, which render an accurate estimate of the average botanical composition of the herbage over the whole period impossible. The figures do, however, undoubtedly represent the truth sufficiently nearly for our present purpose. But before referring to the yield of nitrogen, it may be remarked, in passing, how much greater is the increase of gramineous produce by the use of purely mineral manures in this mixed herbage than in the case of gramineous crops grown separately. The interesting question arises, how far the result is due to the direct action of the mineral manures in enabling the grasses to form much more stem and seed—that is, the better to manure—which, as a matter of fact, they are found to do? or how far the increased growth is to be explained by an increased accumulation of combined nitrogen available for the grasses in the upper layers of the soil, as the result of the increased growth of the Leguminosæ induced by the potass-manure, as already illustrated by the results obtained in alternating clover and barley, and in an actual course of rotation?

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* Mean of four separations only, namely, 1862, 1867, 1872 and 1875.

† Including potass six years, 1856–1861; without potass, fourteen years, 1862–1875.

‡ Including potass twenty years, 1856–1875.

Referring to the yield of nitrogen, it is seen that, without manure, it has diminished during the last as compared with the first ten years; but that the average is thirty-three pounds per acre, per annum, or considerably more than with a gramineous crop grown separately.

With super-phosphate of lime alone, the yield of nitrogen over the first ten, the second ten, and the twenty years, is very nearly the same as without manure. It is slightly higher as is also the total amount of produce; but while the quantity contributed by gramineous species is rather more, that yielded by leguminous species is less, and that by species belonging to other orders more than without manure.

With super-phosphate of lime, and sulphates of potass, soda and magnesia, during the first six years, but no potass during the last fourteen years (plot 8), the amount of both gramineous and leguminous herbage is very much increased; and that of the leguminous produce was especially so during the earlier years. The result is a yield of 55·4 lbs. of nitrogen per acre, per annum, over the first ten years, of only 38·1 lbs. over the second ten years, and of 46·3 lbs. over the twenty years.

With the complex mineral manure, including potass each year throughout the period of twenty years (plot 7), leguminous species contribute about one-fifth of the whole produce, or very much more than in either of the other cases. The result is an annual yield of 55·2 lbs. of nitrogen over the first ten years; of even slightly more, or fifty-six lbs., over the second ten years: and of 55·6 lbs. over the whole period of twenty years—that is, considerably more than twice as much as would be yielded by a gramineous crop grown separately on arable land. It may here be observed that, while in the case of the first three plots referred to, the produce of the mixed herbage diminished over the second as compared with the first ten years, that of plot 7, with the potass manure, and so much leguminous herbage, increased slightly over the second compared with the first ten years. Finally, it may be remarked on this point, how comparatively uniform is the average yield of produce by all other species other than the gramineous and the leguminous on the four very differently manured plots.

Here again, then, the results relating to the growth of species of many different natural orders growing together, like those relating to the growth of individual species grown separately, show that those of the leguminous family, and probably those of various other orders also, have the capacity of assimilating much more nitrogen over a given area than species of the order Gramineæ.

Assuming for the sake of argument that the yield of nitrogen by the Gramineæ grown separately may be explained, as already suggested, by reference to the amount of combined nitrogen acquired from the measured aqueous deposits from the atmosphere, together with that condensed within the pores of the soil, and that derived from previous accumulations within it, the question arises, can the greatly increased yield by other plants be so accounted for? or, if not, how otherwise may it be explained? We will endeavor to weigh the evidence bearing upon this point.

Is the combined nitrogen in the atmosphere the source of the assimilated nitrogen?—It so happens that the plants which do gather, or which have been supposed to gather nitrogen more readily than the Gramineæ, have obviously a different character of foliage; as, for instance, the "root crops"—turnips and the like; and the leguminous crops—beans, peas, clover, etc. An obvious explanation, therefore, which will be found in books of authority, is that these so distinguished "broad-leaved plants" have the power of taking up nitrogen in some form from the atmosphere, in a degree, or in a manner, not possessed by the narrow-leaved gramineous plants. It is true that Adolph Mayer in Germany, and Schlösing in France, have experimentally shown that plants can take up nitrogen by their leaves from ammonia supplied to them in the ambient atmosphere. But I think I am right in saying that the conclusion of both of these experimenters is that this action takes place in a very immaterial degree in natural vegetation.

In reference to this subject, I may observe that the results of the determinations of the ammonia in the atmosphere by different experimenters, and in different localities, vary very greatly; and it may be concluded that a shower of rain will wash out much of it. According to M. Schlösing's statement of the results of his recent determinations of the ammonia in the air of Paris (Compt. Rend., lxxxi, p. 1252 et seq.), it ranges from one part in about 12,500,000, to one part in about 260,000,000 of air by weight. If, for the purpose of illustration, we assume that, on the average, the ambient atmosphere in the open country—in Europe, at any rate—will contain one part of ammonia in 60,000,000 of air, or one part of nitrogen as ammonia in about 50,000,000 of air, the atmosphere would thus contain more than 8,000 times less nitrogen as ammonia than carbon as carbonic acid. But cereal crops contain one part of nitrogen to about thirty of carbon, and leguminous crops, one of nitrogen to fifteen, or fewer, of carbon. On these assumptions, the ambient atmosphere would contain a proportion of nitrogen as ammonia, to carbon as carbonic acid, about 267 times less than that of nitrogen to carbon in cereal produce, and about 534 times (or more) less than that in leguminous produce. It is true that water would absorb very much more nitrogen as ammonia, or dissolve very much more as carbonate or bi-carbonate of ammonia, than it would of carbon as carbonic acid under equal circumstances. Hence, there would appear to be a compensating quality for the small actual and relative amount of nitrogen as ammonia in the atmosphere, in the greater solubility or absorbability of the compounds in which nitrogen exists, than of the carbonic acid in which the carbon is presented. Further, it can hardly be to merely a greater extent of leaf or above-ground surface that the result could be attributed. Thus, though a bean and a wheat crop may yield about equal amounts of dry matter per acre, the bean produce would contain from two to three times more nitrogen, and approximate measurements show that a wheat plant offers a greater external superfices in relation to a given weight of dry substance than a bean plant, and greater still therefore in relation to a given amount of nitrogen fixed. If, then, the bean can in some way take up more nitrogen from the atmosphere than the wheat, the result must be due to character and function, rather than to mere extent of surface above ground. It may, however, be observed that, as a rule, even those of the leguminous crops which are grown for their ripened seed, maintain their green and succulent surface, over a more extended period of the season of active growth, than do the gramineous corn crops.

It may safely be asserted, then, that neither direct experimental evidence, nor a consideration of the chemistry and the physics of the subject, would lead to the conclusion that the plants which assimilate more nitrogen over a given area than others, do so by virtue of a greater power of absorbing by their leaves combined nitrogen from the atmosphere in the form of ammonia. And here it may be said in passing that the argument would be still stronger against the supposition that nitric acid in the atmosphere supplies directly to the leaves of plants any important amount of the nitrogen they assimilate.

But apart from the more purely scientific considerations bearing upon the question, we believe that our statistics of nitrogen-production are themselves sufficient to justify the conclusion that, at any rate, the "broad-leaved" *root-crops*, turnips and the like, to which the function has with the most confidence been attributed, do not take up any important proportion of their nitrogen by their leaves from combined nitrogen in the atmosphere. Thus, it has already been shown, that the yield of nitrogen in these crops, even with the aid of complex mineral manures, was in the later years reduced to a lower point than that in any other crop; the percentage of nitrogen in the upper layers of the soil was also reduced to a lower point than with any other crop. The evidence of this kind is, however, admittedly not so conclusive in regard especially to plants of the leguminous family.

Is the free nitrogen of the atmosphere the source of the assimilated nitrogen?—But as about four-fifths of the atmosphere which surrounds the leaves of plants consist of free nitrogen, why should not this be a source to them of the nitrogen they require? To assume that it is so is such an obvious and easy way out of so many difficulties, that this assumption has from time to time been freely made, and much experimental investigation has been undertaken on the point with the most conflicting results. It is now nearly forty years since Boussingault showed that there was a greater assimilation of nitrogen over a given area in a rotation of crops than he could well account for; and almost from that time to this he has been occupied with investigations of very various kinds, sometimes on the atmosphere, sometimes on meteoric waters, sometimes on plants, and sometimes on soils, the main object of which has obviously been to throw light on the question of the sources of the nitrogen of vegetation. And almost for as long a period as Boussingault, Mr. Lawes and myself have devoted much thought and investigation to the same end.

On this point, of whether or not plants assimilate the free nitrogen of the atmosphere, leaving out of view, for lack of time and space, the experiments and conclusions of several others who have worked on the subject on a less comprehensive scale, I will first briefly direct attention to the most comprehensive series of experiments, the results of which led the author to conclude that the free nitrogen of the atmosphere is taken up and assimilated by the leaves of plants.

During the years 1849, 1850, 1851, 1852, 1854, 1855, and 1856, M. G. Ville, of Paris, made numerous experiments on this subject. His plants were generally enclosed in a glass case, and his soils consisted of washed and ignited sand, sand and brick, or sand and charcoal. They were sometimes supplied with a current of unwashed air, sometimes with a current of washed air, and they were sometimes in free air; sometimes a known quantity of ammonia was supplied to the air of the apparatus, and sometimes known quantities of nitrate were supplied to the soil. Lastly, a great variety of plants were experimented upon. M. G. Ville's results are summarized in Table V, below.

TABLE V.—*Summary of the Results of* M. G. VILLE'S *Experiments, to determine whether Plants assimilate free Nitrogen.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, and Air; and Manure, if any.	In Products.	Gain or Loss.	
1849: *Current of unwashed air supplying* 0·001 *grams Nitrogen as Ammonia.**				
Cress	0·0260	0·1470	0·1210	5·6
Large Lupins	0·0640	0·0640	0·0000	1·0
Small Lupins	0·0640	0·0470	−0·0170	0·7
	0·1550	0·2580	0·1030	1·7
1850: *Current of unwashed air supplying* 0·0017 *grams Nitrogen as Ammonia.**				
Colza (plants)	0·0260	1·0700	1·0440	41·1
Wheat	0·0160	0·0310	0·0150	1·9
Rye	0·0130	0·0370	0·0240	2·8
Maize	0·0290	0·1380	0·0990	4·4
	0·0857	1·2660	1·1803	14·8
1851: *Current of washed air.**				
Sunflower	0·0050	0·1570	0·1520	31·4
Tobacco	0·0040	0·1750	0·1710	43·7
Tobacco	0·0040	0·1620	0·1580	40·5

*** Recherches Expérimentales sur la Végétation, par M. Georges Ville. Paris, 1853.**

TABLE V.—*Continued.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, and Air; and Manure, if any.	In Products.	Gain or Loss.	
1852: *Current of washed air.**				
Autumn Colza	0·0480	0·2260	0·1780	4·7
Spring Wheat	0·0290	0·0650	0·0360	2·2
Sunflower	0·0160	0·4080	0·3920	25·5
Summer Colza	0·1730	0·5950	0·4220	3·4
Summer Colza	0·1050	0·7010	0·5960	6·7
1854: *Current of washed air (under superintendence of a Commission).*				
Cress	0·0099	0·0097	−0·0002	1·0
Cress	0·0038	0·0530	0·0492	13·9
Cress	0·0039	0·0110	0·0071	2·8
1854: *Current of washed air (closed, under superintendence of a Commission).*†				
Cress	0·0063	0·0350	0·0287	5·6
1855 and 1856: *In free air, with* 0·5 *grams Nitre* =0·069 *Nitrogen.*‡				
Colza	0·0700	0·0700§	0·0000	1·0
Colza	0·0700	0·0660§	−0·0040	0·9
Colza	0·0700	0·0680§	−0·0020	1·0
1855 and 1856: *In free air, with* 1 *gram Nitre* =0·138 *Nitrogen.*‡				
Colza	0·1400	0·1970§	0·0570	1·41
Colza	0·1400	0·3740§	0·2340	1·67
Colza	0·1400	0·2160§	0·0760	1·54
Colza	0·1400	0·2500§	0·1100	1·79
1856: *In free air, with* 0·792 *grams Nitre* =0·110 *Nitrogen.**				
Wheat	0·1260	0·2180§	0·0920	1·7
Wheat	0·1260	0·2240§	0·0980	1·8
1855: *In free air, with* 1·72 *grams Nitre* =0·238 *Nitrogen.**				
Wheat	0·2590	0·3080§	0·0490	1·2
1856: *In free air, with* 1·765 *grams Nitre* =0·244 *Nitrogen.**				
Wheat	0·2650	0·2170§	−0·0480	0·8
Wheat	0·2650	0·3500§	+0·0850	1·3

* Recherches Expérimentales sur la Végétation, par M. Georges Ville. Paris, 1853.

† Compt. rend., 1855. ‡ Recherches Expérimentales sur la Végétation, 1857.

§ In plants only.

We have already discussed the results of M. G. Ville, as well as those of others, in a paper published in the Philosophical Transactions for 1859, and in a somewhat condensed form in the Journal of the Chemical Society, vol. xvi, 1863; and we can only very briefly refer to them in this place. The column of actual gain or loss of nitrogen is seen to show in one case a gain of more than one gram of nitrogen; the amount of it in the products being more than forty-one fold that supplied as combined nitrogen in the seed, and air. This result was obtained with colza. Those obtained with wheat, rye, or maize, showed very much less of both actual and proportional gain. Experiments with sunflower and tobacco showed a less actual gain than that with colza; but still it amounted in one case, with sunflower, to more than thirty, and in two, with tobacco, to more than forty-fold of that supplied. In M. G. Ville's experiments (as a glance down the last two columns in the table will show), although he still had generally some gain, it was usually both actually and in proportion to the quantity supplied considerably less than in his earlier ones.

M. G. Ville attributed the gain, in some cases, to the large leaf-surface. In explanation of the assimilation of free nitrogen by plants, he calls attention to the fact that nascent hydrogen is said to give ammonia, and nascent oxygen nitric acid, with free nitrogen, and he asks, "Why should not the nitrogen in the juices of the plant combine with the nascent carbon and oxygen in the leaves?" He refers to the supposition of M. De Luca, that the nitrogen of the air combines with the nascent oxygen given off by the leaves of plants, and to the fact that the juice of some plants (mushrooms) has been observed to ozonize the oxygen of the air, and he asks, "Is it not probable, then, that the nitrogen dissolved in the juices will submit to the action of the ozonized oxygen with which it is mixed, when we bear in mind that the juices contain alkalies, and penetrate tissues, the porosity of which exceeds that of spongy platinum?"

The experiments of M. Boussingault, and of ourselves, on the other hand, have not given an affirmative answer to the question whether plants, by their leaves, take up and assimilate free nitrogen of the air.

M. Boussingault commenced his experiments on this subject in 1837, and Table VI, which follows, summarizes his results, obtained at intervals from that date up to 1858.

TABLE VI.—*Summary of the Results of* M. BOUSSINGAULT'S *Experiments, to determine whether Plants assimilate free Nitrogen.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, or Plants; and Manure, if any.	In Products.	Gain or Loss.	
1837: *Burnt soil, distilled water, free air, in closed summer-house.*[*]				
Trefoil	0·1100	0·1200	+0·0100	1·09
Trefoil	0·1140	0·1560	+0·0420	1·37
Wheat	0·0430	0·0400	−0·0030	0·93
Wheat	0·0570	0·0600	+0·0030	1·05
1838: *Conditions as in* 1837.[†]				
Peas	0·0460	0·1010	+0·0550	2·20
Trefoil (Plants)	0·0330	0·0560	+0·0230	1·70
Oats (Plants)	0·0590	0·0530	−0·0060	0·90
1851 and '52: *Washed and ignited pumice with ashes, distilled water, limited air, under glass shade, with Carbonic Acid.*[‡]				
Haricot, 1851	0·0349	0·0340	−0·0009	0·97
Oats, 1851	0·0078	0·0067	−0·0011	0·86
Haricot, 1852	0·0210	0·0189	−0·0021	0·90
Haricot, 1852	0·0245	0·0226	−0·0019	0·92
Oats, 1852	0·0031	0·0030	−0·0001	0·97
1853: *Prepared pumice, or burnt brick, with ashes; distilled water, limited air, in glass globe, with Carbonic Acid.*[‡]				
White Lupin	0·0480	0·0483	+0·0003	1·01
White Lupin	0·1282	0·1246	−0·0036	0·97
White Lupin	0·0349	0·0339	−0·0010	0·97
White Lupin	0·0200	0·0204	+0·0004	1·02
White Lupin	0·0399	0·0397	−0·0002	1·00
Dwarf Haricot	0·0354	0·0360	+0·0006	1·02
Dwarf Haricot	0·0298	0·0277	−0·0021	0·93
Garden Cress	0·0013	0·0013	0·0000	1·00
White Lupin	0·1827	0·1697	−0·0130	0·93
1854: *Prepared pumice with ashes, distilled water, current of washed air, and Carbonic Acid, in glazed case.*[§]				
Lupin	0·0196	0·0187	−0·0009	0.95
Dwarf Haricot	0·0322	0·0325	+0·0003	1·01
Dwarf Haricot	0·0335	0·0341	+0·0006	1·02
Dwarf Haricot	0·0339	0·0329	−0·0010	0·97
Dwarf Haricot	0·0676	0·0666	−0·0010	0·99
Lupin	0·0180	0·0334	−0·0021	0.94
Lupin	0·0175			
Cress	0·0046	0·0052	+0·0006	1·13

[*] Ann. Ch. Phys., II, lxvii, (1838).

[†] Ibid., lxix.

[‡] Ann. Ch. Phys., III, xli, (1854).

[§] Ann. Ch. Phys., III, xliii, (1855).

TABLE VI.—*Continued.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, or Plants; and Manure, if any.	In Products.	Gain or Loss.	
1851, '52, '53, and '54: *Prepared soil, or pumice with ashes; distilled water, free air, under glased case.**				
Haricot (dwarf), 1851	0·0349	0·0380	+0·0031	1·09
Haricot, 1852	0·0213	0·0238	+0·0025	1·12
Haricot, 1853	0·0293	0·0270	−0·0023	0·92
Haricot (dwarf), 1854	0·0318	0·0350	+0·0032	1·10
Lupin (white), 1853	0·0214	0·0256	+0·0042	1·20
Lupin, 1854	0·0199	0·0229	+0·0039	1·15
Lupin, 1854	0·0376	0·0387	+0·0020	1·05
Oats, 1852	0·0031	0·0041	+0·0010	1·32
Wheat, 1853	0·0064	0·0075	+0·0011	1·17
Garden Cress, 1854	0·0259	0·0272	+0·0013	1·05
1858: *Nitrate of Potassium as Manure.*†				
Helianthus	0·0144‡ 0·0255‡	0·0130 0·0245	−0·0014 −0·0010	0·90 0·96

M. Boussingault's soils consisted of burnt soil, washed and ignited pumice, or burnt brick; his experiments were sometimes in free air, sometimes in a closed vessel with limited air, sometimes with a current of washed air, and sometimes in free air, but under a glass case. When the plants were enclosed, a supply of carbonic acid was provided, and in a few cases known quantities of nitre were supplied as manure.

The last two columns of Table VI show the actual and proportional gain of nitrogen in M. Boussingault's experiments. It will be observed that in his earliest experiments, those in free air, in a summer-house, the leguminous plants, trefoil and peas, did indicate a notable gain of nitrogen; but in all his subsequent experiments there was generally either a slight loss, or, if a gain, it was represented in only fractions, or low units, of milligrams. After twenty years of varied and laborious investigation of the subject, M. Boussingault concluded that plants have not the power of taking up and assimilating the free nitrogen of the atmosphere.

Our own experiments on this subject were commenced in 1857, and the late Dr. Pugh, of the Pennsylvania State Agricultural College, devoted between two and three years to the investigation at Rothamsted. Mr. Lawes has contributed one complete set of the apparatus employed to this exhibition. The arrangement, and the results obtained up to that date, are fully described in the papers already referred to, published in the Philosophical Transactions for 1859, and in the Journal of the Chemical Society in 1863. They may be briefly described as follows:—

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* Ann. Ch. Phys., Sér. III, xliii, (1855).

‡ Compt. rend., xlvii, (1858).

‡ Nitrogren in seed and nitrate.

The soils used were ignited, washed, and re-ignited, pumice, or soil. The specially made pots were ignited before use, and cooled over sulphuric acid under cover. The pots, with their plants, were enclosed under a glass shade resting in the groove of a specially made hard-baked glazed stone-ware lute-vessel, mercury being the luting material. Under the shade, through the mercury, passed one tube for the admission of air, another for its exit, and another for the supply of water or solutions to the soil; and there was an outlet at the bottom of the lute-vessel for the escape of the condensed water into a bottle affixed for that purpose, from which it could be removed and returned to the soil at pleasure. A stream of water being allowed to flow into a large stone-ware Wolff's bottle (otherwise empty), air passed from it through two small glass Wolff's bottles containing sulphuric acid, then through a long tube filled with fragments of pumice saturated with sulphuric acid, and lastly through a Wolff's bottle containing a saturated solution of ignited carbonate of soda; and, after being so washed, the air enters the glass shade, from which it passes, by the exit tube, through an eight bulbed apparatus containing sulphuric acid, by which communication with the unwashed external air is prevented. Carbonic acid is supplied as occasion may require, by adding a measured quantity of hydrochloric acid to a bottle containing fragments of marble, the evolved gas being passed through one of the bottles of sulphuric acid, through the long tube, and through the carbonate of soda solution, before entering the shade.

It will be observed that, by the arrangement described, the washed air is forced, not aspirated, through the shade, and the pressure being thus the greater within the vessel, the danger of leakage of unwashed air from without inward is lessened. In 1857, twelve sets of such apparatus were employed; in 1858 a larger number, some with larger lute-vessels, and shades; in 1859 six, and in 1860 also six. The whole were arranged, side by side, in the open air, on stands of brick-work, as described in the papers referred to, and shown in the apparatus exhibited. Drawings of some of the plants grown were also exhibited, and the published results are summarized in Table VII.

Table VII.—*Summary of the Results of Experiments made at Rothamsted, to determine whether Plants assimilate Free Nitrogen.*

			Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
			In Seed, and Manure, if any.	In Plants, Pot and Soil.	Gain or Loss.	
With no *combined Nitrogen supplied beyond that in the seed sown.*						
Gramineæ.	1857.	Wheat	0·0080	0·0072	−0·0008	0·90
		Barley	0·0056	0·0072	+0·0016	1·11
		Barley	0·0056	0·0082	+0·0026	1·46
	1858.	Wheat	0·0078	0·0081	+0·0003	1·04
		Barley	0·0057	0·0058	+0·0001	1·02
		Barley	0·0063	0·0056	−0·0007	0·89
	1858. A*	Wheat	0·0078	0·0078	0·0000	1·00
		Oats	0·0064	0·0063	−0·0001	0·98
Leguminosæ.	1857.	Beans	0·0796	0·0791	−0·0005	0·99
	1858.	Beans	0·0750	0·0757	+0·0007	1·01
		Peas	0·0188	0·0167	−0·0021	0·89
Other Plants.	1858.	Buck Wheat	0·0200	0·0182	−0·0018	0·91
With *combined Nitrogen supplied beyond that in the seed sown.*						
Gramineæ.	1857.	Wheat	0·0329	0·0383	+0·0054	1·16
		Wheat	0·0329	0·0331	+0·0002	1·01
		Barley	0·0326	0·0328	+0·0002	1·01
		Barley	0·0268	0·0337	+0·0069	1·25
	1858.	Wheat	0·0548	0·0536	−0·0012	0·98
		Barley	0·0496	0·0464	−0·0032	0·94
		Oats	0·0312	0·0216	−0·0096	0·69
	1818. A*	Wheat	0·0268	0·0274	+0·0006	1·02
		Barley	0·0257	0·0242	−0·0015	0·94
		Oats	0·0260	0·0198	−0·0062	0·76
Leguminosæ.	1858.	Peas	0·0227	0·0211	−0·0016	0·93
		Clover	0·0712	0·0665	−0·0047	0·93
	1858. A*	Beans	0·0711	0·0655	−0·0056	0·92
Other Plants.	1858.	Buck Wheat	0·0308	0·0292	−0·0016	0·95

The upper part of the table shows the results obtained in 1857 and 1858 in the experiments in which no combined nitrogen was supplied beyond that contained in the seed sown. The drawings show how extremely restricted was the growth under these conditions, and the figures in the table show that neither with the Gramineæ, the Leguminosæ, nor with buckwheat, was there in any case a gain of three milligrams of nitrogen indicated. In most cases there was much less gain than this, or a slight loss. There was in fact nothing in these results to lead to the conclusion that either the Gramineæ, the Leguminosæ, or the buckwheat had assimilated free nitrogen.

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* These experiments were conducted in the apparatus of M. G. Ville.

The lower part of the table shows the results obtained in 1857 and 1858, in the experiments in which the plants were supplied with known quantities of combined nitrogen in the form of a solution of ammonium sulphate applied to the soil. The gains or losses range a little higher in these experiments, in which larger quantities of nitrogen were involved, but they are always represented by units of milligrams only, and the losses are higher than the gains. Further, the gains, such as they are, are all in the experiments with the Gramineæ, while there is in each case a loss with the Leguminosæ, and with the buckwheat. On this point it should be stated that the growth was far more healthy with the Gramineæ than with the Leguminosæ, which are even in the open fields very susceptible to the vicissitudes of heat and moisture, and were found to be extremely so when enclosed under glass shades. It might be objected, therefore, that the negative result, with the Leguminosæ are not so conclusive as those with the Gramineæ. However this may be, taking the results as they stand, there is nothing whatever in them to lead to the conclusion that either the Gramineæ or the Leguminosæ can take up and assimilate the free nitrogen of the atmosphere. We, indeed, do not hesitate to conclude from our own experiments, as Boussingault did from his, that the evidence is strongly against the supposition that plants can so avail themselves of the free nitrogen of the atmosphere.

Independently of the action suggested as possible by M. G. Ville, that is between free nitrogen and nascent or ozonized oxygen within the plant itself, it has been supposed that the free nitrogen of the atmosphere may unite with the nascent oxygen, or ozone, as the case may be, evolved by the plant, and so yield nitric acid. In our papers above referred to we have given reasons for supposing that such actions are not likely to take place; but whether they do or do not, it is at any rate certain that in our own experiments we have not been able to persuade plants to avail themselves of this happy faculty of producing their own nitrogenous food. With regard to the action supposed possibly to take place externally to the plant itself, if it were in any material degree operative, we should expect some, at least, of the resulting combined nitrogen to be collected in the aqueous deposits from the atmosphere; but we have seen how inadequate is the amount of combined nitrogen in those deposits to account for the yield of nitrogen, even of the Gramineæ, and still less can it satisfactorily explain the yield in the Leguminosæ and other plants.

[To be continued.]

ART. XII.—*On the Orbit of the planet Urda* (167); by C. H. F. PETERS.

THIS planet was discovered as a star of 12th magnitude on August 28th ult., and the observations obtained, after applying corrected star positions, are the following, each being the mean from twelve comparisons by ring-micrometer.

1876.	Ham. Col. m. t.			App. α (167).			App. δ (167).		
	h	m	s	h	m	s	°	′	″
Aug. 28,	14	18	21	21	58	32·22	−11	23	41·2
" 30,	13	35	16	21	57	2·27	−11	33	23·3
Sept. 12,	12	48	43	21	48	16·70	−12	31	14·2
" 15,	12	19	28	21	46	38·63	−12	42	24·8

It seems that the planet has not been seen anywhere else; and the orbit therefore had to be evolved from the foregoing observations alone, however unequally distributed over an interval of only eighteen days. I succeeded by computing first a circular orbit, which served for freeing the observations from aberration and parallax, and then using of the eight data the four longitudes and the two extreme latitudes. The final ellipse arrived at is the following:

Epoch, 1877, Jan. 0·0 Berlin m. t.

$$L = 317^\circ\ 43'\ 27{\cdot}4''.$$
$$\pi = 32^\circ\ 39'\ 22{\cdot}2'' + 50{\cdot}24''\ (t. - 1876).$$
$$\Omega = 170^\circ\ \ 7'\ 25{\cdot}4'' + 49{\cdot}25''\ (t. - 1876).$$
$$i = 1^\circ\ 42'\ 14{\cdot}5'' - 0{\cdot}47''\ (t. - 1876).$$
$$\varphi = 18^\circ\ 10'\ 30{\cdot}6''.$$
$$\mu = 614{\cdot}475''.$$
$$\log a = 0{\cdot}507668.$$

Of these elements, three, viz., node, inclination and major axis, bear a remarkable resemblance to those of Gerda (122). Moreover, the element of the excentricity, as it is derived from so short an arc in our orbit, remains necessarily very uncertain. The same is the case, though in less degree, and for the same reason, with the position of the apsides, or the longitude of perihelion. Only the remaining 6th element, therefore, can decide, whether the two planets are identical. Now, for the same epoch we have for Gerda L = 168° 46′, and as the correctness of Mr. Stockwell's computations of Gerda are fully confirmed by observations upon this planet made at Berlin in April last, it is proved that Urda is distinct from Gerda.

The fact of two planets moving in the same plane, with the same time of revolution, having also the line of apsides in common (our elements, if correct, show a longitude of perihelion nearly 180° distant from Gerda's), but with a widely different excentricity, is worthy of note. And it is therefore still more desirable, that Urda should not pass unnoticed in its next opposition, which will occur in January, 1878, and when the planet will be of the 12·7 magnitude.

Litchfield Observatory of Hamilton College, Jan. 6, 1877.

ART. XIII.—*Principles of Compensation in Chronometers;* by J. B. JAMES, M.D., Trenton, N. J.

"FOR one to know, is nothing, unless others also may know," is an aphorism of modern progressive science; for it is only from what has been attained that step by step further progress may be made. This it is which impels the writer to offer some considerations on the principles of compensation in chronometers.

It may be assumed as an axiom of general application, that an error should be avoided whenever it is possible, rather than compensated; yet this plain axiom is disregarded in the compensation balance, in two respects.

1st. What is the action of the laminated rim as affected by change of temperature? The end of the arm is commonly regarded as a fixed point, which it is not; for its distance from the center is changed by change of temperature; and whatever weight is here, if its distance from the center is changed, that change must be compensated at the other end of the segment; and therefore this is not the place for mean-time screws; while between these two ends of the segment, there must be a point whose distance from the center undergoes little or no change, and where its weight requires no compensation for change of temperature. This point of uniform distance from the center, when ascertained, should therefore be regarded as the *fixed point;* and if the compensation required were only for the changes in the balance itself, it would be absolutely perfect; for as the one end of the segment recedes from the center, the other approaches it—the one merely taking the place of the other; and this would be in effect true whether the ends were equidistant from the fixed point or not—the longer segment requiring only the less weight. It is the attempt to compensate, in the balance, for changes in the length and elasticity of the spring that creates the necessity for a *secondary* compensation.

This principle of compensation for temperature has been practiced in the pocket chronometer, with marked success, by Henry B. James, of Trenton N. J., for some years. He attaches the outer end of the balance spring to the elastic arm of a laminated convolute, which, at the same time that it compensates, more or less, for changes in the spring, permits a more free movement of the balance; while, parting the rim of a balance having equal thicknesses of brass and steel in its structure, at a distance of one-sixth of its circumference from the arm, he assumes the middle of the longer portions, and the free ends of the shorter, as places where weight requires no compensation, the longer portions carrying on their free ends only a moderate weight for the compensation needed.

2d. The work performed by the balance near its center of motion is a source of error that has been generally neglected. It is a settled principle of dynamics, that "if a body revolving on an axis strike an immovable obstacle at the *center of percussion*, the point of suspension will not be affected by it;" while "if the blow be struck in any other point, a part of its motion will be employed in endeavoring to continue the motion." Thus if we take into the hand at one end a club of uniform thickness, and by a motion from the wrist as a center strike an obstacle at a distance of one-third its length from the other end, the hand feels no effect from the blow; but if it be struck by any other point, the hand will receive a part of the blow,—greater as it is further from the point named. Now the "center" or *line* of percussion of a balance is in or near the rim, and the resistance to its motion, by means of the spring and escapement, is near its center; and the force thus lost, as to the movement of the spring and escapement, is transmitted to the pivots of the balance as useless friction. The errors arising from the relative positions and directions of these forces and that of gravitation, and the changes therein from change of position or latitude, from the density of the air and the space in which the balance moves, varying friction from the oil, lurches on shipboard or jolts in the pocket, and from the different rates of expansion of metals as they affect the friction of the balance or pivots or the working of the escapement—these furnish a problem to ascertain or compensate their average effects, sufficiently complicated to account for the little progress that has been made in perfecting the chronometer. For however small may be their effects on a single movement of the balance, when it is multiplied by fourteen to eighteen thousand for every hour, or three or four hundred thousand in twenty four hours, they become so readily appreciable as to deserve attention and amelioration.

Now if we can remove from the balance pivots this intermittent and useless friction, leaving only its own greatly reduced and uniform amount, unchanged by change of position or temperature, a balance of greater momentum could be substituted, which, in a proportionate degree would lessen the effect of the remaining sources of error, and this, it is believed, can be accomplished by simple and practicable mechanism.

ART. XIV.—*Notes on the Vespertine Strata of Virginia and West Virginia;* by WILLIAM M. FONTAINE.

(Concluded from page 48.)

Vespertine of Augusta and Rockingham Counties.

My principal examinations in this quarter were made at "North River Gap," in the northern corner of Augusta county, in the "Dora Coal Field." In this part of the State the eastern edge of a fractured portion of the Vespertine area seems to have been pressed down against the massive Lower Silurian limestone, along the line of fault which runs on the west side of the "Valley of Virginia." This has resulted in the overturn of the strata westward, and the catching of a narrow synclinal belt of the middle member under the massive sandstones of the lower portion. These, by their resistance to erosion, have preserved from removal the more destructible strata of the coal-bearing rocks, and standing up in huge ribs, form the core of the Great North Mountain, here called locally, "Narrow Back." As might be expected, especially in the mountain itself, the amount of contortion and crushing is immense.

The sandstones are changed to quartzites, with all granular structure obliterated. The shales which contain the coal, from their more yielding nature, have suffered most. Where they are exhibited in the western face of the mountain, they are thrust through the coal seams, and wrapped in the most complicated contortions. In places they seem to have been drenched with water holding silica in solution. They sometimes contain lumps and strings of quartz, deposited by such waters. Yet with all this, they are true shales, being rendered only more compact and harder. This is another striking example of the difference in the amount of metamorphic action, produced in sandstones and shales, when subjected to the same influences, and of the insufficiency of mechanical disturbance to produce more than the first stages of metamorphism.

The convoluted and disturbed strata of the mountain dip southeast at a high angle. After passing it to the west, the dip flattens rapidly, and while the rocks of the mountain are inverted, we now find them in their normal position. We may compare the structure of the belt to a fish-hook, with its shank turned westward, the bend representing the mountain. The material of the hook would represent the sandstones of the lower Vespertine, while we may conceive the middle member with its coals as filling the curve, and resting upon the shank. It will thus be seen that the number of coal beds will be doubled by overlap in the west face of the mountain. The strata have suffered much from erosion, and show only the lower and middle members. It is however by no means certain that the upper member of red shales was ever present. The increase in the coarseness and amount of the sandstones underlying the coal strata seems rather to indicate its former absence. No limestone appears here.

I did not make a complete section at this point of the strata supposed to represent the Catskill. Enough however was seen to show that red shales appear here at the same horizon as at Lewis Tunnel, but the amount is not so great, and they are now changed to red argillaceous flags. The upper members here are somewhat massive liver-colored sandstones, which graduate upward into the white sandstones of the lower Vespertine. The Catskill? strata seem to be considerably thicker in this region than at Lewis Tunnel.

The sandstones of the lower member of the Vespertine cannot be separated by any distinct dividing line from the above mentioned rocks. But, assuming for their base the strata which do not show a predominance of the red color, they show a thickness of about 400 feet. All are highly siliceous, and lie in pretty massive beds. No dividing line can be drawn in this mass of rock, but a gradual change may be traced. At the base it is brownish gray, then gray, and finally white, passing near the top into gray flags. The white portion is about 200 feet thick, being mainly a massive quartzite, but showing in the lower portion some conglomerate bands. Over the above mentioned rocks are about 40 feet of gray flags, in the top of which is the lowest coal bed. This stratum may be taken as the lower portion of the middle member. The following is the section from the lowest coal ascending to the highest:

1. Black siliceous shales, (floor).
2. Coal, 18 inches.
3. Argillaceous sandstone, 4 feet.
4. Black siliceous shale, 6 inches.
5. Sandstone, 8 inches.
6. Black siliceous shale, 4 feet.
7. Sandstone, 1 foot.
8. Black shale, 5 feet.
9. Coal, 2–2½ feet.
10. Black siliceous shale, 12 ft.

No. 2 is very impure, and where it is best has several partings of shale. It is very variable in the amount of coal, and often runs almost entirely into shale. No. 6 has some thin strings of coal, as is the case with No. 8. No. 9 is the most constant bed, and has the largest amount of clear coal. In the top of No. 10 a few thin strings of coal sometimes occur.

The remaining rocks above No. 10 are gray and bluish-gray sandy shales, showing in some places abundant plant impressions. The exposures are too poor to allow any approximation to their thickness.

The coal here is a true anthracite, of pretty good quality. Attempts have been made, from time to time, to work it, but without success. The large amount of carbon in some of the shale immediately associated with the coal, its highly glazed aspect (from friction), and the intimate manner in which it is mixed with the true coal, have led to an exaggerated estimate of the thickness of the beds. This mistake was aided by the imperfect manner in which the coal was exposed in the outcrops. From these causes I was myself led, some two years ago, on my first visit to the place, to think the amount of coal greater than it has proved to be. Of late the somewhat extensive exploration made in this field by the Royal Land Co., of Virginia, has demonstrated that the amount of coal is too small, and its crushing too great, to render it of commercial value.

The Vespertine strata in Montgomery County.

I have not had the good fortune to procure a copy of Prof. Lesley's "Description of the South Virginian Coal Region of Montgomery and Wythe counties," published in vol. ix, Proc. Am. Phil. Soc. No doubt this would have aided me greatly in my study of the Vespertine of Montgomery, to which my investigations were confined.

The Vespertine strata in Montgomery county occupy two distinct areas, which require separate descriptions. The most important of these is the narrow tract lying on the northern side of the great fault, which passes just south of Brush Mountain. This is but the continuation, to the south, of the belt just described in Augusta county.

The smaller area lies about two miles south of Brush Mountain, from which it is separated by a narrow belt of Lower Silurian limestone, and about two and a half miles northwest of Christiansburg. This small area, so far as I know, has never received the notice that it deserves. Prof. Rogers simply speaks of it as an outlier of Vespertine, similar in character to that of Brush Mountain. But little was known of it then, and even up to the late war, when its coals were examined and worked to some extent. Since then the good quality and thickness of the beds, as well as the ease with which they may be worked, have led to their farther development.

The structure of this field, which bears the name of Price's Mountain, is one of the most curious products of the force which has produced the numerous faults in this region. It is a belt, with an anticlinal structure, about seven miles long, and 2½ wide, running nearly east and west, (more accurately, 10° N. of E.).

The maps of Virginia show a mountain chain, under the name Alleghany, running by Christiansburg in a northerly direction, to meet Brush Mountain. This is merely a watershed, and does not appear above the surrounding country as mountain. The eastern end of the Vespertine belt in question is found in this watershed. From that point, where the strata stand at the general level of the country, they run nearly in a westerly direction toward New River, and pass about 2½ miles northwest of Christiansburg. The strata of the eastern end are the red marlites of the upper member. In passing westward they begin to rise into an anticlinal elevation, which soon attains the height of about 300 feet, which height is maintained for about 3½ miles, showing a continuous ridge. This portion bears the name of Price's Mountain. Farther west, toward the river, the ridge is broken up into hills, and then finally disappears before the stream is reached. I am informed that no trace of the strata is to be found west of New River, where the rock is all limestone.

As the ridge rises in passing west, the coal-bearing strata of the middle member begin to appear through the red marlites, and where it is highest, the upper part of the lower member appears in the crest. In this portion the coals are worked. Here we find the red marlites forming an outer band on each side of the ridge, and cut off abruptly north and south by the Lower Silurian limestone, which also sweeps around the eastern end. The coal strata occupy the foot, and reach some distance up the slope, on each side. The field seems to be a prism of Vespertine strata, engulfed by a double fault in the limestone, with its eastern end tipped lower than the middle and western portions. The dip of course is nearly north and south, away from the crest, and toward the limestone.

The amount of contortion and rubbing exhibited by the strata is surprisingly small. The roof and floor of the openings made are as uniform and smooth as those of our upper coals of the West. As a consequence, the coal is worked with ease, and unlike that of Brush Mountain, two miles off, shows but little rubbing, and may be taken out in blocks of any size. There are two beds here as in Brush Mountain, being evidently the same. The amount of slate partings is however smaller in Price's Mountain, and the coal thicker.

As the middle member containing the coal beds is evidently similar to that exposed in Brush Mountain, while the exposure here is not so good, the section of it taken in that mountain will suffice for both localities. The same may be said of the lower member. The upper red beds however are much better displayed here, and the section of them, taken from the northern foot of Price's Mountain northward to the limestone, will be given as a representative one. We find here these rocks well exposed, with a steady northward dip, until they are suddenly cut off by the limestone.

The dip on the north side is somewhat steeper than on the south side, being in the former case 30° N.N.W., and in the latter, 26° S.S E. The coal of the upper bed on the north side is somewhat thicker than that on the south side. The lower bed is essentially the same on both sides. The lower bed everywhere averages about two feet. It is enclosed in gray flags, and separated from the upper by about forty feet of the same kind of rock.

An average section for the upper bed on both sides, is as follows, commencing at the top:

1. Black slate, (roof).
2. Coal, 12 inches.
3. Slate, 12 inches.
4. Coal, 2½ feet.
5. Slate, 7 inches.
6. Coal, 10 inches.
7. Slate, (floor).

No. 4 sometimes runs up to three feet, and the other layers of coal show occasionally an increase of several inches in thickness.

The following section, omitting details, will give the character of the red upper member, commencing below:

1. Interstratification of brown sandstone, and red shale, 50 feet.
2. Red and mottled marlites, with some brown sandstone, 440 ft.
3. Thinly fissile, red shales, " " " " 600 feet.

A regular change may be traced in the character of these sediments. No. 1 and No. 2, in the lower portion, have a larger proportion of sandstone. But in the greater portion of No. 2, especially the middle and upper parts, and in all of No. 3, the sandstone appears only in occasional beds. The lower portion of No. 2 is often mottled with spots and streaks of gray and green. The indications are that the strata were deposited during a steadily progressing subsidence.

This thickness of 1090 feet of red shales and marlites is suddenly cut off on the northern side, by the Lower Silurian limestone, which throughout this region has a southeast dip, and shows a considerable amount of alteration. No remnant of the Lower Carboniferous, or Lewisburg limestone, is seen here, and if it were ever present, it has been removed by erosion. It is clear that this mass of red strata was deposited prior to this limestone, if it were ever formed here. In any case we would have a great development of the upper member, as compared with the same near Lewis Tunnel, and this agrees well with the development of the two underlying members in this region.

I am inclined, however, to think that all of these beds were not deposited before the limestone. The increasing fineness of the upper portion No. 3, and other indications that this part was formed in comparatively deep and quiet waters, make it quite probable that No. 3 is the representative here of the limestone. So far as I know the limestone has been seen by no one so far to the east. The sudden cutting off of the Lower Carboniferous limestone by faults in its most easterly known exposures, renders it difficult to draw any conclusions from a change of thickness.

Brush Mountain lies to the north of Price's Mountain, and is separated from it by a belt of Lower Silurian limestone about 1½ miles wide. Its structure is very simple. The northern foot is composed mainly of Chemung strata, while the central mass is formed of the lower member of the Vespertine, which extends some distance down the southern slope. A portion of the southern face and foot of the mountain is composed of the middle or coal-bearing member, while a band of red rocks belonging to the upper member forms the foot-hills next to the limestone belt. By the great fault, mentioned before as running on the western side of the valley of Virginia, this mass of strata has been brought down so as to abut against the Lower Silurian limestone. Though there has been no overturn of the strata, yet some slight shifting of the beds has been produced, causing a considerable amount of rubbing and crushing. This has made itself felt, especially in the coal, which in consequence is much more fractured and rubbed than that of Price's Mountain, yet by no means so much so as that of Augusta and Rockingham counties. Poverty Creek, after flowing for some distance along the north side, cuts directly through this mountain, and gives a good section of all the strata of the Vespertine. The dip is 80° S.S.E. toward the fault. My section was taken along this creek, commencing on the north side in the Chemung beds, and proceeding south to the upper member of the Vespertine.

The Chemung beds show the same character here as at Lewis Tunnel. The same alternations of flaggy sandstone and shales, with thin layers containing numerous impressions of shells, are found. These beds are to be seen within a space of 400 feet, under the lowest of the Vespertine strata. This interval was too much concealed to enable me to determine whether it is occupied by Chemung beds, or strata which may be the equivalents of the Catskill. If the latter are present here, they must be less than 400 feet thick. I am inclined to think that they are entirely absent, having been replaced by the greatly thickened lower beds of the Vespertine. The following is the section of the latter in ascending order.

Lower member of the Vespertine.

1. **Massive white conglomerate and sandstone, 80 feet.**
2. **Massive white sandstone, with layers of conglomerate, 150 feet.**
3. **Thin-bedded white siliceous sandstones, 100 feet.**
4. **White and yellowish flags, marked with red spots and streaks, 300 feet.**
5. **Siliceous gray sandstones and flags, 300 feet.**

Total for the lower member, 930 feet.

No. 1 is a conglomerate of remarkable coarseness, and contains only subordinate bands of coarse white sandstone. Most of the pebbles are from a half an inch to an inch in size, but many are two inches in diameter, and flat. The quartzose matter is all pure white, and plainly derived from the Potsdam and underlying quartzites, as may be easily seen from the nature of the larger pebbles. The smaller pebbles are rounded. The great coarseness, pure siliceous character, and white color of this stratum, contrast in the most striking manner with the underlying Chemung beds, and point to a radical change in the conditions of deposition.

No. 2 is a highly siliceous, white sandstone, with subordinate bands of smaller pebbles. A gradual change from a highly siliceous character to a more argillaceous one, may be traced as we ascend in the series. No. 4 is marked with streaks and spots of red, and begins to show some argillaceous matter, especially toward the top, while in No. 5 a large amount of this material is present. This latter is heavy bedded toward the bottom, and more flaggy toward the top.

Middle member of the Vespertine.

1. Argillaceous gray sandstones, 200 feet.
2. Coal. Upper bed, thickness not exposed.
3. Massive and flaggy gray sandstones, interstratified, 120 feet.
4. Bluish, argillaceous gray flags, 350 feet.

Total for the middle member, 670 feet.

The lower coal-bed was not seen in this section. No. 3 is rather more massive and siliceous here than in Price's Mountain. In No 4, occasional beds 10 to 15 feet thick occur, more massive and siliceous than the great body of the mass. Next above No. 4 come the red beds of the upper member.

The coals of Brush Mountain lie in two beds, identical with those of Price's Mountain, but, as stated before, the amount of slate partings is greater, as is the disturbance to which they have been subjected. Still the upper bed here is also worked to a considerable extent. The lower bed has a sandstone floor and roof. It is about three feet thick, with a slate parting in the middle, from five to ten inches thick. This bed was formerly worked on a small scale, but is now entirely neglected. The upper bed is separated from this by from thirty-five to forty feet of gray flags. About half way between the two, at some of the openings, a small seam twelve inches thick, is reported to exist. The following is the section of the upper bed:

No. 1. Bottom slate.
" 2. Coal, 8 inches.
" 3. Slate, 3 inches.
No. 4. Coal, 6 inches.
" 5. Slate, 1 inch.
" 6. Coal, 6 inches.

No. 7. Slate, 10 inches.
" 8. Mining dirt, 6 inches.
" 9. Main coal, 20–30 inches.
" 10. Slate, 8 inches.
No. 11. Slaty coal, 6 inches.
" 12. Mining dirt, 6 inches.
" 13. Coal and slate, 20 inches.
" 14. Coal, 10 inches.

No. 2 is quite soft, and a good material for blacksmiths. The "bearing in" is done in Nos. 8 and 12. These are composed of crushed coal and slate. All the material above and below them is neglected. The roof above No. 14 is a coarse sandstone with some pebbles. In some localities two small seams occur above this bed, within the space of forty-five feet. These small seams may occur in Price's Mountain, but were not seen.

The coal is all semi-bituminous, some of it approaching an anthracite. The coal of the lower bed is harder than that of the upper. In Price's Mountain the coal of the main portion of the upper bed is a handsome, firm material, with a dull lustre, much resembling the natural coke of the Richmond coal field. It seems here to be remarkably free from sulphur. The coal of Brush Mountain is usually glazed by friction, and seems to have more sulphur. An analysis by Prof. Rogers makes these coals to contain: 14 p. c. bituminous matter, 80 p. c. carbon, and 6 p. c. of ash. The ash is very fine, and of a white color. The coal is said to be excellent for grates and stoves.

It will be seen from the above account that there has been a very marked thickening of the Vespertine as we proceed from north to south through the state, accompanied by an increase in the amount of coal contained in it. This increase seems to be largely at the expense of the supposed Catskill beds. It is in conformity with a law of increase which holds good for all the strata from the Devonian to, and including, the Lower Barren Measures of the Upper Coals.

Plants.

I have, whenever opportunity offered, made a collection of the plant impressions, but owing to their peculiar mode of distribution, and the small amount of excavation made in these strata, I have, as yet, not been able to procure a collection large enough to be offered as representative of the series. Hence I will not attempt to give here anything but a few general statements, which may be greatly modified by farther discoveries.

So far as my observations go, the plants of this series of strata occur at any given locality, with but few species, while these are marked by the great number of individuals which they exhibit. These species are widely distributed, and perfectly characteristic of the series, at least as compared with the flora of the beds above the Conglomerate. The most important and characteristic plants are the following:

1. *Lepidodendron.* The forms of Lepidodendron are the most abundant and widely distributed. They are all characterized by small leaf-scars.

2. *Palæopteris.* This shows two types. By far the most abundant and widely distributed is the form with narrow elliptical leaflets, like *P. Jacksoni.* We find much less abundantly, a second type with broad flabellate leaflets, like *Palæopteris obtusa.*

3. *Triphyllopteris.* To this, I consider Mr. Meek's *Cyclopteris Virginiana*, and *C. Lesueuriana*, as belonging. The latter plant, with possibly a similar species, is widely distributed and very abundant in some localities, forming all the impressions to be found.

I have nowhere seen any impressions of Sigillaria, Calamites, Sphenopteris, and others of the most common plants in the productive coal-measures. In only one case have I seen a specimen of Neuropteris, and this was a remarkably fine one, of *N. flexuosa*, found at Lewis Tunnel. This place has yielded a much greater variety of plants than any other locality visited by me. Of course this negative evidence, in the absence of extended exploration, cannot be taken as excluding the former presence of these plants in the Vespertine. Still it is peculiar that with the many hundreds of specimens seen at widely distant localities, none of those plants noted above as not seen, should have been met with.

Art. XV.—*Contributions from the Sheffield Laboratory of Yale College.* No. XLI.—*On the Chemical composition of the flesh of Hippoglossus Americanus;* by R. H. Chittenden.

The *Hippoglossus Americanus* of Gill, or halibut as the fish is commonly called, is found in the waters of the Atlantic ocean from Newfoundland to Cape Hatteras. The halibut belongs to the class of white-blooded fish, of which the *Merlangus vulgaris*, or whiting, is a typical representative. The flesh of the halibut is of a fine white color, quite delicate and tender, and is highly valued for food, especially in certain portions of the United States.

A fresh sample obtained at the market yielded by analysis

	No. 1.	No. 2.
Water	82·85	82·90
Solids	17·15	17·10
Ash	1·08	1·08
Fat	1·21	1·32
Nitrogen	2·02	2·00
Phosphoric acid (P_2O_5)	·37	

The fresh flesh of the whiting yielded Payen*—

Water	82·95
Solids	17·05
Ash	1·08
Fat	·38
Nitrogen	2·41

According to Pavy the flesh of the whiting which is eaten so extensively in England, is tender, easily digested, and highly nutritious. A comparison of these two analyses shows but very little difference in the chemical composition of the flesh of the halibut and whiting.

The flesh of the halibut dried at 100° C. yielded by analysis:

	No. 1.	No. 2.
Carbon	50·30	50·46
Hydrogen	7·36	7·51
Nitrogen	11·70	11·66
Ash	6·32	6·39
Oxygen	24·32	23·98
	100·00	100·00
Fat	7·08	7·15

The ash of the flesh gave by analysis:

Silica	·32
Chlorine	11·11
Carbonic acid	1·13
Sulphuric acid	1·30
Phosphoric acid	34·36
Iron	·19
Lime	·15
Magnesia	2·43
Potash	37·07
Soda	12·22
Lithia	trace
	100·28

The ash for the analysis was obtained by carbonizing a large quantity of the flesh, then leaching this carbonized mass with hot water to remove chlorides. The residue left undissolved by the water was then ignited at a higher temperature until burned white. The aqueous solution of the chlorides was then poured over the insoluble residue and the whole heated until the water was completely driven off. This residue was ignited gently and yielded a perfectly white ash.

By a backward glance at these analyses we see that the food value of the flesh of the halibut is not of a low order, but compares favorably with the flesh of other fish of the same class.

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* Compt. Rend., xxxix, 318.

ART. XVI.—*Notice of Darwin on the Effects of Cross- and Self-Fertilization in the Vegetable Kingdom;*[*] by ASA GRAY.

MR. DARWIN, in the title of his new work, refers only incidentally to adaptations for cross-fertilization,—a subject which has given origin to a copious literature since he opened it anew in his book on the Fertilization of Orchids, in 1862. A new edition of this latter book is on the eve of publication in England, and we believe that this author's scattered papers on cross-fertilization, as secured by various contrivances, are about to be collected, revised, and issued in a book form. In the volume now before us, Mr. Darwin deals with the effects of cross- and self-fertilization, recounts at length the experiments he has devised and carried on, collects and criticises the results, glances at the means of fertilization, and the habits of insects in relation to it, and ends with some theoretical considerations or inferences suggested by or deduced from the facts which have been brought to light.

If writing for the popular press, we should be bound to say that this book is not light reading. Three-fourths of its pages and of the chapters are devoted to the details of the experiments and the sifting and various presentation of the results; and the remainder, although abounding in curious facts and acute suggestions, is yet of a solid character. The bearings of various points upon what is called "Darwinism" are merely touched or suggested, here and there, in a manner more likely to engage the attention of the thoughtful scientific than of the general reader.

That cross-fertilization is largely but not exclusively aimed at in the vegetable kingdom, is abundantly evident. As Mr. Darwin declares, "it is as unmistakably plain that innumerable flowers are adapted for cross-fertilization, as that the teeth and talons of a carnivorous animal are adapted for catching prey, or that the plumes, wings, and hooks of a seed are adapted for its dissemination." That the crossing is beneficial, and consequently the want of it injurious, is a teleological inference from the prevalence of the arrangements which promote or secure it,—an inference the value of which increases with the number, the variety, and the effectiveness of the arrangements for which no other explanation is forthcoming. That the good consisted in a re-invigoration of progeny, or the evil of close-breeding in a deterioration of vigor, was the suggestion first made (so far as we know), or first made prominent, by Knight, from whom Darwin adopted it. However it be as to animals, there was until now no clear and direct evidence that cross-fertilization in the vegetable kingdom did re-invigorate. Indeed, the contrary might be inferred from the long and seemingly indefinite perpetuation of bud-propagating varieties, which have no fertilization at all. But the inference from this is not as cogent as would at first appear. For, although bud-propagation is, we think, to be considered as the extreme of close-breeding, yet in it the amount of material contributed by parent to offspring is usually vastly more than in sexual reproduction: and, accordingly, the diminution to an injurious degree of any inherited quality or essence might be correspondingly remote. Yet, as sexual reproduction may be and often must be much closer in plants than it can be in most animals, the ill effects of self-fertilization, or the good of cross-fertilization, might the sooner be noticeable. Mr. Darwin arranged a course of experiments to test this question, prosecuted it as to some species for eleven years; and the main object of this volume is to set forth the results.

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[*] The Effects of Cross- and Self-Fertilization in the Vegetable Kingdom; by CHARLES DARWIN, M.A., F.R.S., etc. London: Murray. (New York: D. Appleton & Co.) 12mo, pp. 482. 1876.

Ipomœa purpurea, the common Morning Glory of our gardens, was the leading subject. The flowers of this species self-fertilize, but must also be habitually cross-fertilized, as they are visited freely by humble-bees and other insects. Ten flowers of a plant in a greenhouse were fertilized with their own pollen; ten others were crossed with pollen from a different plant. The seeds from both were gathered, allowed to germinate on damp sand, and as often as pairs germinated at the same time the two were planted on opposite sides of the same pot, the soil in which was well mixed, so as to be uniform in composition. "The plants on the two sides were always watered at the same time and as equally as possible, and even if this had not been done the water would have spread almost equally to both sides, as the pots were not large. The crossed and self-fertilized plants were separated by a superficial partition, which was always kept directed towards the chief source of the light, so that the plants on both sides were equally illuminated." Five pairs were thus planted in two pots, and all the remaining seeds, whether or not in a state of germination, were planted on the opposite sides of a third pot, so that the plants were crowded and exposed to a very severe competition. Rods of equal diameter were given to all the plants to twine up, and as soon as one of each pair had reached the summit, both were measured. But a single rod was furnished to each side of the crowded pot, and only the tallest plant on each side was measured. This was followed up, for ten generations; the close fertilization being always self-fertilization, i. e., by pollen to stigma of the same flower; the crossing, between individuals in successive generations of this same stock, except in special instances, when an extraneous stock was used as one parent,—to eminent advantage, as will be seen.

The difference in vigor between the cross-bred and the close-bred progeny, as measured by early growth, was well marked throughout. In the mean of the ten generations it was as 100 to 77. In the tenth generation it was 100 to 54, that is, five cross-bred plants grew to the average height of 93·7 inches while the close-bred were reaching the average of 50·4 inches. This was a notably greater difference than in any previous generation. But this was probably accidental or anomalous; for it was not led up to by successive steps. Indeed, the difference in the first generation was a trifle greater than the average of all ten, being as 100 to 76. The second generation was as 100 to 79; the third as 100 to 68; the fourth as 100 to 86; the fifth as 100 to 75; the sixth as 100 to 72; the seventh as 100 to 81; the eighth as 100 to 85; the ninth as 100 to 79; the tenth, as already stated, 100 to 54. The general result is made striking in the following illustration.

"If all the men in a country were on an average six feet high, and there were some families which had been long and closely inter-bred, these would be almost dwarfs, their average height during ten generations being only four feet eight and one-quarter inches." (p. 53.)

It is remarkable that the difference between the close-bred and the cross-bred individuals should have been as great as it was in the first generation; and, this being the case, it might have been expected that the difference would have gone on increasing in the succeeding generations. If self-fertilization is injurious, the ill effects would be expected to be cumulative. "But," instead of this, "the difference between the two sets of plants in the seventh, eighth, and ninth generations taken together is less than in the first and second generations together." Upon this Mr. Darwin remarks: "When, however, we remember that the self-fertilized and crossed plants are all descended from the same mother plant, that many of the crossed plants in each generation were related, often closely related, and that all were exposed to the same conditions, which, as we shall hereafter find, is a very important circumstance, it is not at all surprising that the difference between them should have somewhat decreased in the later generations." (p. 56.)

Further light was thrown upon these points by two kinds of subsidiary experiments. In one case, the cross was made between two flowers of the same plant of *Ipomœa*, while other flowers were self-fertilized as before. On raising seedlings from the two lots, it was found that such crossing gave no superiority: indeed, the offspring of the self-fertilized flowers appeared to be rather more vigorous than the close-crossed. And other experiments led to the same conclusion, namely, that there was no particular benefit from cross-fertilization on the same plant. In the other case, the cross was made not only between the flowers of distinct plants, but between those from different sources, and which had presumably grown under somewhat different conditions. For instance, several flowers of the ninth generation of crossed plants of *Ipomœa* were crossed with pollen taken from the same variety, but from a distant garden. The resulting seedlings showed the benefit of the fresh stock remarkably, being as much superior in vigor to those of the tenth inter-crossed generation as the latter were to the self-fertilized plants of the corresponding generation. In height they were as 100 to 78, over the ordinary inter-crossed; and in fertility, as 100 to 51. Indeed, Mr. Darwin's main conclusion from all his observations is, "that the mere act of crossing by itself does no good. The good depends on the individuals which are crossed differing slightly in constitution, owing to their progenitors having been subjected during several generations to slightly different conditions, or to what we call in our ignorance spontaneous variation."

The greater constitutional vigor of the crossed plants of *Ipomœa* was manifested in other ways than their rate or amount of growth; they better endured exposure to a low temperature or sudden changes of temperature; they blossomed earlier; and they were more fertile. The difference in fertility varied greatly in degree (the extremes in different experiments and in different generations being 100 to 99 and 100 to 26), but was always sustained. Also, "the impaired fertility of the self-fertilized plants was shown in another way, namely, by their anthers being smaller than those in the flowers on the crossed plants. This was first observed in the seventh generation, but may have occurred earlier. . . . . The quantity of pollen contained in one of the self-fertilized was, as far as could be judged by the eye, about half of that contained in one from a crossed plant. The impaired fertility of the self-fertilized plants of the eighth generation was also shown in another manner, which may often be observed in hybrids—namely, by the first-formed flowers being sterile."

Similar experiments were made, but not carried to the same extent, upon fifty-seven other species of plants, belonging to fifty-two genera, and to thirty great natural families, the species being natives of various parts of the world. The results—the details and discussion of which occupy the bulk of this volume—vary greatly, some plants making a better, and others a less good showing for the advantage of cross-fertilizing, and this advantage manifesting itself in different ways, some in vigor or amount of growth, some in hardiness, most in fertility; but with twelve cases in which the crossed plants show no marked advantage over the self-fertilized. There were, however, fifty-seven cases in which the crossed exceeded the self-fertilized by at least five per cent, generally by much more.

Increase of vigor, as evinced in growth, appears generally to be accompanied by increased fertility; but sometimes the good of crossing was manifested only in productiveness, i. e., in a larger amount of seed. This proved to be the case in *Eschscholtzia*, in which—strange to say—self-fertilized plants of several generations were superior in size and weight to inter-crossed plants, even when the crossing was between flowers derived on one side from American, on the other from English seed, from which, upon Mr. Darwin's view, the maximum benefit should be gained. This instance, however, stands alone. Yet it is approached by several others, in a manner which might have negatived the general conclusions of the research, if they had been hastily gathered from a small number of trials.

For example, in the sixth self-fertilized generation of *Ipomœa purpurea*, one of these plants took the lead of its competitor, kept it almost to the end, and was ultimately overtopped only by half an inch on a total height of several feet. To ascertain whether this exceptionally vigorous plant would transmit its power to its seedlings, several of its flowers were fertilized with their own pollen, and the seedlings thus raised were put into competition with ordinary self-fertilized and with inter-crossed plants of the corresponding generation. The six children of Hero (the name by which this individual was designated), beat the ordinary self fertilized competitors at the rate of 100 to 84, and the inter-crossed competitors at the rate of 100 to 95; and in the next generation the self-fertilized grand-children beat those from a cross between two of the children at the rate of 100 to 94. In the next generation the seedlings were raised in winter in a hot-house, became unhealthy, and the experiment terminated without marked result. Moreover the remarkable vigor of growth in Hero and its progeny was attended by somewhat increased fertility. Here, then, an idiosyncracy arose, from some utterly unknown cause,—a spontaneous variation of constitution, which was transmitted to posterity, and which gave all the benefit of cross-fertilization, and somewhat more, both as to vigor and fertility. A similar idiosyncracy made its appearance in the third generation of seedlings of *Mimulus luteus*.

Discordant or anomalous facts like these seem confusing, even though too few to affect seriously the grand result of the numerous experiments; but upon Darwinian principles, in which adaptations are ultimate results, they are to be expected, as a consequence of the general and apparently vague proclivity to vary.

In Foxglove,—the flowers of which are naturally self-sterile or nearly so, and in which crossing gave a marked advantage over self-fertilizing, both as to growth and productiveness,—a decided, though small advantage, appeared to come from the crossing of flowers on the same plant.

In *Origanum vulgare*, crosses were made between different plants of a large clump, long cultivated in a kitchen-garden, which had evidently spread from a single root by stolons, and which had become in a good degree sterile, as is usual under such conditions. The crossing caused rather more seed to form; but the seedlings from the crossed did not surpass in growth those of the self-fertilized; "a cross of this kind did no more good than crossing two flowers on the same plant of *Ipomœa* or *Mimulus*. Turned into the open ground, and both self- and cross-fertilized the following summer, and equal pairs of the resulting seeds planted on opposite sides of two very large pots, the crossed plants from seed showed a clear superiority over their self-fertilized brethren, at the rate of 100 to 86. But this excess of height by no means gives a fair idea of the vast superiority in vigor of the crossed over the self-fertilized plants. The crossed flowered first and produced thirty flower-stems, while the self-fertilized produced only fifteen, or half the number. The pots were then bedded out, and the roots probably came out of the holes at the bottom, and thus aided their growth. Early in the following summer, the superiority of the crossed plants, owing to their increase by stolons, over the self-fertilized plants, was truly wonderful. . . . Both the crossed and the self-fertilized plants being left freely exposed to the visits of bees, manifestly produced much more seed than their grandparents,—the plants of original clumps still growing close by in the same garden, and equally left to the action of bees."

These few cases must here suffice, and they give a fair general idea of the main results reached,—somewhat qualified, however, by certain instances in which little or no benefit was observed. Let it be remarked that while most of the cases show decided and unequivocal good from the crossing, none of them unequivocally tell to the contrary, as the advantage appears sometimes in one direction, sometimes in another. "Thus, the crossed and self-fertilized plants of *Ipomœa*, *Papaver*, *Reseda odorata*, and *Limnanthes* were almost equally fertile, yet the former exceeded considerably in height the self-fertilized plants. On the other hand the crossed and self-fertilized plants of *Mimulus* and *Primula* differed to an extreme degree in fertility, but by no means to a corresponding degree in height or vigor."

We must wholly omit — among many other things — the interesting account of self-sterile plants, meaning here not those in which the pollen does not reach the stigma unaided, but those in which it is impotent, or nearly so, when applied, although efficient upon the stigma of another individual. *Verbascum*, *Passiflora*, *Corydalis*, and many Orchids afford instances of this sort. In these the advantage of cross-fertilization rises to a necessity. A noteworthy fact respecting them (of which Mr. Darwin makes much) is, that such self-sterility, or the reverse, is influenced by slight changes in the conditions, such as difference in temperature, grafting on another stock, and the like. In South Brazil, Fritz Müller found that for six generations all his plants of *Eschscholtzia Californica* were completely sterile, unless supplied with pollen from a distinct plant, when they were completely fertile. This was not the case in English plants, which, when covered by a net, set a considerable number of capsules, the seeds of which, by weight, were as 71 to 100 of those on plants intercrossed by bees. These Brazilian seeds, sent to England, yielded plants with moderately self-fertile flowers, and this limited self-fertility was increased in two generations of English growth. Conversely, seeds from English plants grown in Brazil were more self-fertile than those reared in Brazil for several generations; yet "one which did not flower the first year, and was thus exposed for two seasons to the climate of Brazil, proved quite self-sterile, like a Brazilian plant, showing how quickly the climate had acted on its sexual constitution." Having observed that certain individuals of Mignonette were self-sterile, Mr. Darwin secured several such plants under separate nets, and by inter-crossing these for a few generations, obtained plants which inherited this peculiarity, so that "without doubt a self-sterile race of Mignonette could easily have been established."

Nine of the twelve chapters are devoted strictly to the effects of cross and self-fertilization. The tenth considers the "means of fertilization." Cross-fertilization is favored or ensured by: 1, the separation of the sexes; 2, the maturity of the male and female sexual elements at different periods; 3, dimorphism or even trimorphism; 4, various mechanical contrivances; 5, the more or less complete inefficiency of a flower's own pollen on its stigma, and the prepotency of pollen from any other individual over that from the same plant. We understand that Mr. Darwin is just now occupied in revising and extending his various papers upon these topics, with a view to their publication in a volume. Here he gives a list of plants which, when insects are excluded, are either quite sterile or produce less than half the number of seeds yielded by unprotected plants. This is followed by a list of plants which, when protected from insects, are either quite fertile or yield more than half the number of seeds produced by unprotected plants.

"Each of these lists contains by a mere accident the same number of genera, viz., forty-nine. The genera in the first list include sixty-five species, and those in the second sixty species; the Orchideæ in both being excluded. If the genera in this latter order, as well as in the Asclepiadeæ and Apocynaceæ, had been included, the number of species which are sterile if insects are excluded would have been greatly increased; but the lists are confined to species which were actually experimented on. The results can be considered as only approximately accurate, for fertility is so variable a character, that each species ought to have been tried many times. The above number of species, namely, 125, is as nothing to the hosts of living plants; but the mere fact of more than half of them being sterile within the specified degree, when insects are excluded, is a striking one; for whenever pollen has to be carried from the anthers to the stigma in order to ensure full fertility, there is at least a good chance of cross-fertilization. I do not, however, believe that if all known plants were tried in the same manner, half would be found to be sterile within the specified limits; for many flowers were selected for experiment which presented some remarkable structure; and such flowers often require insect-aid." (p. 370.)

It is worth noticing that *Trifolium repens* and *T. pratense* (the common white and red clovers) have a place in the first list; *T. arvense* and *T. procumbens* in the second. Darwin refers to Mr. Miner's statement that "in the United States, hive-bees never suck the red clover," and says it is the same in England, except from the outside through holes bitten by humble-bees; yet that H. Müller has seen them visiting this plant in Germany, for the sake both of pollen and nectar, which latter they obtained by breaking apart the petals. Darwin has not qualified his statement, long ago made, of the complete sterility of red clover protected from insects; but Mr. Meehan asserts that protected plants are fertile in this country, without, however, giving details or the rate of fertility. In *T. arvense*, "the excessively small flowers are incessantly visited by hive and humble-bees; when insects were excluded the flower-heads seem to produce as many and as fine seeds as the exposed heads."

As to cross-fertilization, "the most important of all the means by which pollen is carried from the anthers to the stigma of the same flower, or from flower to flower, are insects, belonging to the orders of Hymenoptera, Lepidoptera, and Diptera; and in some parts of the world, birds." In a note the author cites all the cases known to him of birds fertilizing flowers. These are chiefly humming-birds. "In North America they are said to frequent the flowers of *Impatiens*" (for which Gould, Trochilidæ, is referred to as authority, and a reference is given to the Gardeners' Chronicle, which we find relates to something else in South

America); and this is all concerning the United States. Can it be that there are no references in print to the most familiar fact that our humming-bird is very fond of sucking the blossoms of Trumpet Creeper (*Tecoma radicans*) and of Honeysuckles? Both these are, in size and arrangement of parts, well adapted to be thus cross-fertilized.

Flowers are rendered conspicuous to birds and still more to insects, by bright colors. And as "almost every fruit which is devoured by birds presents a strong contrast in color with the green foliage, in order that it may be seen, and its seeds disseminated," so the proportionally large size and the bright colors of the corolla, or in some cases the equally bright hues of adjoining parts of the flower, or of the inflorescence, are correlated to visiting insects,—have come to pass, as Darwin would say, in consequence of the visits of insects, through the advantages in vigor and productiveness gained by cross-fertilization. He is ready to adopt even the idea of Conrad Sprengel, which seemed to be so fanciful, that marks and streaks on the corolla serve as guides to the nectary: for, although insects are well able to discover the nectar without the aid of guiding marks, yet they are of service by facilitating the search and enabling insects to suck a greater number of blossoms within a given time, which is tantamount to greater opportunity for cross-fertilization.

That odors attract insects is certain and many flowers are both conspicuous and odoriferous, while others make up in fragrance what they lack in show. "Nägeli affixed artificial flowers to branches, scenting some with essential oils, and leaving others unscented: and insects were attracted to the former in an unmistakable manner."

"Of all colors white is the prevailing one; and of white flowers a considerably larger proportion smell sweetly than of any other color, namely, 14·6 per cent; of red, only 8·2 per cent are odoriferous. The fact of a larger proportion of white flowers smelling sweetly may depend in part on those which are fertilized by moths requiring the double aid of conspicuousness in the dusk and of odor. So great is the economy of nature, that most flowers which are fertilized by crepuscular or nocturnal insects emit their odor chiefly or exclusively in the evening. Some flowers, however, which are highly odoriferous depend solely on this quality for their fertilization, such as the night-flowering stock (Hesperis) and some species of Daphne; and these present the rare case of flowers which are fertilized by insects being obscurely colored."

"The shape of the nectary and of the adjoining parts are likewise related to the particular kinds of insects which habitually visit the flowers; this has been well shown by H. Müller by his comparison of lowland species, which are chiefly visited by bees, with Alpine species belonging to the same genera, which are visited by butterflies."

"Pollen contains much nitrogen and phosphorus—the two most precious of all the elements for the growth of plants—but in the case of most open flowers, a large quantity of pollen is consumed by pollen-devouring insects, and a large quantity is destroyed during long-continued rain. With many plants this latter evil is guarded against, as far as is possible, by the anthers opening only during dry weather, by the position and form of some or all of the petals, by the presence of hairs, etc.; also, as Kerner has shown in his interesting essay, by the movements of the petals or of the whole flower during cold and wet weather. In order to compensate the loss of pollen in so many ways, the anthers produce a far larger amount than is necessary for the fertilization of the same flower. I know this from my own experiments on Ipomœa, given in the Introduction; and it is still more plainly shown by the astonishingly small quantity produced by cleistogene flowers, which lose none of their pollen, in comparison with that produced by the open flowers borne by the same plants; and yet this small quantity suffices for the fertilization of all their numerous seeds. Mr. Hassall took pains in estimating the number of pollen-grains produced by a flower of the Dandelion, and found the number to be 243,600, and in a Pæony 3,654,000 grains. The editor of the 'Botanical Register' counted the ovules in the flowers of *Wisteria sinensis*, and carefully estimated the number of pollen-grains, and he found that for each ovule there were 7,000 grains." (pp. 376, 377.)

These are probably fair averages of the numerical ratio of pollen to ovules in flowers which are adapted to be fertilized by insect agency. Their meaning in "the economy of nature" is seen by a comparison on the one hand with *anemophilous*, i. e., wind-fertilized, flowers, in most of which there is a vastly greater disproportion between the numbers—compensating for inevitable waste—and on the other with *cleistogenous* flowers, namely those small and less developed blossoms which some plants produce in addition to the ordinary sort, and which fertilize as it were in the bud, necessarily by their own pollen. Here is no waste, and accordingly the anthers are very small, and the pollen-grains not many times more than the ovules: also such flowers are never brightly colored, never odoriferous, and they never secrete nectar.

The only advantages of this close-fertilization which we can think of are sureness and strict likeness; both of which are quite as well secured by budding-reproduction. Now, as cleistogene flowers are borne, we believe, chiefly and perhaps only, by species whose normal blossoms are adapted for insect-fertilization, they must be regarded as a subsidiary arrangement, a safeguard against failure of proper insect-visitation. As the volume before us amply shows, this failure is in general provided for by a more or less wide margin of self-fertilization in the very flowers which are adapted for crossing. In *Impatiens*, *Viola*, and the like, it is provided for by separate flowers, the special adaptations of which are unmistakable.

H. Müller appears to have shown "that large and conspicuous flowers are visited much more frequently and by many more kinds of insects than are small inconspicuous flowers. He further remarks that the flowers which are rarely visited must be capable of self-fertilization, otherwise they would quickly become extinct." Mr. Darwin's list seems to show that, as a rule, they are so; yet many very small flowers, like those of *Trifolium arvense*, and small and dingy ones, like those of *Asparagus*, are freely visited by bees; and, conversely, many large and conspicuous flowers which are frequented by insects are none the less self-fertilizable. Throughout we find that such things do not conform to arbitrary or fixed rules; and this favors the idea that the differences have been acquired. Mr. Darwin conjectures that the self-fertilizing capabilities of many small and inconspicuous flowers may be comparatively recent acquisitions, on the ground that, if they were not occasionally intercrossed, and did not profit by the process, all their flowers would have become cleistogenous, "as they would thus have been largely benefited by having to produce only a small quantity of safely protected pollen."

Mr. Darwin's experiments tending to prove that cross-fertilization between flowers on the same plant is of little or no use, he is naturally led to consider the means which favor or ensure their fertilization with pollen from a distinct plant. This must needs take place with diœcious plants, and is likely to occur with the monœcious, and is in some cases secured (as in Walnut and Hazelnut) by some trees being proterandrous and others proterogynous, so that they will reciprocally fertilize each other. In ordinary hermaphrodite species the expansion of only a few blossoms at a time greatly favors the intercrossing of distinct individuals, although, in the case of small flowers it is attended with the disadvantage of rendering the plants less conspicuous to insects. Our common Sundews furnish a good illustration of this. They abound wherever they occur, and are for a long while in blossom, but each plant or spike opens but one flower at a time. The fact of bees visiting the flowers of the same species as long as they can, instead of promiscuously feeding from the various blossoms nearest within reach, greatly favors such intercrossing. So does the remarkable number of flowers which bees are able to visit in a short time (of which mention will be made), and the fact that they are unable to perceive without entering a flower whether other bees have exhausted the nectar. Then dichogamy (the maturation of one sex in a hermaphrodite flower earlier than the other) is so prevalent that it may almost be regarded as the rule; and this ensures such crossing between few-flowered plants, and greatly favors it in the case of spikes, racemes, and the like. For, proterandry being the commonest arrangement, so that the younger flowers act as male, and the older as female, and bees habitually alighting at the bottom and proceeding upward, they carry the pollen from the upper and younger flowers to stigmas of the lower and older flowers of the next spike, and so on. Heterogonism (see this Journal for December, p. 82), which is less common, operates precisely like complete diœcious separation of the sexes in this respect, and with the advantage that all the individuals are seed-bearing. Most of the special arrangements peculiar to certain families, such as Orchids, or to plants—such as *Posoqueria*, with its wondrous mechanism for quickly stopping out access to the stigma when the pollen is violently discharged upon some insect, but opening the orifice the next day—are of a kind to favor the crossing of distinct plants. Prepotency of other pollen, which may accompany the other arrangements or exist independently, acts largely and powerfully toward the same end. Our author investigates this at some length: we cite for illustration a single but a strong case. The stigmas of a long-styled Cowslip were supplied with pollen from the same plant, and again, after twenty-four hours, with pollen of a short-styled, dark-red Polyanthus, a variety of the same species: from the resulting seeds twenty seedlings were raised, and all of them bore reddish flowers; so that the effect of the plant's own pollen, though placed on the stigmas twenty-four hours previously, was destroyed by that of the red variety. The same thing is shown by the impossibility in many cases of raising two varieties of the same species pure if they grow near each other. "No one who has had any experience would expect to obtain pure cabbage-seed, for instance, if a plant of another variety grew within 200 or 300 yards." And a veteran cultivator once had his whole stock of seeds seriously bastardized by some plants of purple Kale which flowered in a cottager's garden half a mile away. Mr. Gordon records a case of the crossing between Primroses and Cowslips through pollen carried by bees over more than two kilometers, or an English mile and a quarter.

We must copy the close of this section—long though it be—because of its capital illustration of the topic in hand, and for the teleological lesson which it teaches.

> **"The case of a great tree covered with innumerable hermaphrodite flowers, seems at first sight strongly opposed to the belief in the frequency of intercrosses between distinct individuals. The flowers which grow on the opposite sides of such a tree will have been exposed to somewhat different conditions, and a cross**

between them may perhaps be in some degree beneficial; but it is not probable that it would be nearly so beneficial as a cross between flowers on distinct trees, as we may infer from the inefficiency of pollen taken from plants which have been propagated from the same stock, though growing on separate roots. The number of bees which frequent certain kinds of trees when in full flower is very great, and they may be seen flying from tree to tree more frequently than might have been expected. Nevertheless, if we consider how numerous are the flowers, for instance, on a Horse-chestnut or Lime-tree, an incomparably larger number of flowers must be fertilized by pollen brought from other flowers on the same tree, than from flowers on a distinct tree. But we should bear in mind that with the Horse-chestnut, for instance, only one or two of the several flowers on the same peduncle produce a seed; and that this seed is the product of only one out of several ovules within the same ovarium. Now we know from the experiments of Herbert and others that if one flower is fertilized with pollen which is more efficient than that applied to the other flowers on the same peduncle, the latter often drop off; and it is probable that this would occur with many of the self-fertilized flowers on a large tree, if other and adjoining flowers were cross-fertilized. Of the flowers annually produced by a great tree, it is almost certain that a large number would be self-fertilized; and if we assume that the tree produced only 500 flowers, and that this number of seeds were requisite to keep up the stock, so that at least one seedling should hereafter struggle to maturity, then a large proportion of the seedlings would necessarily be derived from self-fertilized seeds. But if the tree annually produced 50,000 flowers, of which the self-fertilized dropped off without yielding seeds, then the cross-fertilized flowers might yield seeds in sufficient number to keep up the stock, and most of the seedlings would be vigorous from being the product of a cross between distinct individuals. In this manner the production of a vast number of flowers, besides serving to entice numerous insects and to compensate for the accidental destruction of many flowers by spring-frosts or otherwise, would be a very great advantage to the species; and when we behold our orchard-trees covered with a white sheet of bloom in the spring, we should not falsely accuse Nature of wasteful expenditure, though comparatively little fruit is produced in the autumn."

The Horse-chestnut is not altogether a well-chosen example, for in it, as in our Buckeyes, a very large proportion of the flowers in the thyrsus are usually male, with barely a vestige of pistil. These serve, however, to increase the show, in the manner here illustrated, as well as to furnish abundance of pollen.

The section on anemophilous (wind-fertilized) plants,—their interest as survivals of the earlier phænogamic vegetation,—the speculation as to how, when flying insects came to prevail, an anemophilous plant may have been rendered entomophilous,—how pollen, being a most nutritious substance, would soon have been discovered and devoured by insects, and by adhering to their bodies be carried from anthers to stigma and from one flower to another,—how a waste secretion, such as honey-dew or glandular exudations, may have been developed into nectar and utilized as a lure,—the interesting illustrations of the vast amount of pollen produced by anemophilous plants, and the great distances to which their light pollen is often carried by the wind,—all these inviting topics we must now pass by.

In passing we note the remark that "the excretion of a sweet liquid by glands seated outside of a flower is rarely utilized as a means of cross-fertilization by the aid of insects;" and the sole exception alluded to is that of the bracts of *Marcgraviaceæ.* But a parallel case is afforded by many species of *Euphorbia*, and notably in a striking species cultivated in conservatories, under the name of *Poinsettia.* Here the attraction to the eye is supplied by the intense red coloration of ordinary leaves placed next to the inflorescence, and that to the palate or tongue (if either term may be allowed), by a large cup-shaped gland on the side of the involucre, which contains or surrounds the naked and greatly simplified flowers of both sexes.

That anemophilous plants are prevailingly diclinous (either monœcious or diœcious) is speculatively connected with their antiquity; that they are very largely trees or shrubs is because "the long life of a tree or bush permits of the separation of the sexes with much less risk of evil from impregnation occasionally failing, and seeds not being produced, than in the case of short-lived plants. Hence it probably is, as Lecoq has remarked, that annual plants are rarely diœcious." The number of anemophilous species is comparatively small, but that of individuals of the species strikingly large, so that they form of themselves, in cold and temperate regions, where plant-fertilizing insects are fewer, either vast forests, as of Coniferæ, birches, beeches, etc., or meadows, and glades, as of grasses, sedges, and rushes. Being thus either necessarily or prevailingly cross-fertilizable and gregarious, it is not wonderful that they should hold their own unchanged in various parts of the world. Still their advantage is gained at the expense of the production of an enormous superfluity of pollen, a costly product; and, when diœcious, half the individuals produce no seed. Hermaphroditism with dichogamy, or some equivalent, and transportation by an appeal to the senses and appetites of insects, secures all the advantages with least expenditure. The earliest fertilization in plants took place by the locomotion of the fertilizing or even of the fertilized material, in manner of most of the *Algæ:* mainly losing this as vegetation became terrestrial, the transportation was committed to the winds, and finally in the higher plants more economically consigned to insects.

The eleventh chapter, on the habits of insects in relation to the fertilization of flowers, is one of the interesting and readable, although the shortest. It appears that the prince of naturalists, Aristotle, had observed more than 2000 years ago that the hive-bee visited the flowers of the same species as long as possible before going to a different species. This holds true of all kinds of bees and certain other insects, generally, but not absolutely. Although, as Lubbock has recently proved, bees are much guided by color, yet they hold to the practice just mentioned in spite of difference in this respect, being botanists enough to know that color is not a good specific character. Mr. Darwin has repeatedly seen humble-bees flying straight from a red Fraxinella to a white variety, from one Larkspur to a different colored variety, and the same as to Primroses and Pansies. But two species of Poppy were by some bee treated as one; and H. Müller traced hive-bees from blue hyacinths to blue violets. On the other hand, Darwin's bees fly straight from clump to clump of a yellow Œnothera without turning an inch from their course to Eschscholtzias with yellow flowers which abound on either side. This constancy to species, however, is manifested only when their flowers abound; a fact which may have led Mr. Darwin to his explanation of the reason of it.

> "The cause probably lies in insects being thus enabled to work quicker; they have just learnt how to stand in the best position on the flower, and how far and in what direction to insert their proboscides.* They act on the same principle as does an artificer who has to make half-a-dozen engines, and who saves time by making consecutively each wheel and part for all of them. Insects, or at least bees, seem much influenced by habit in all their manifold operations; and we shall presently see that this holds good in their felonious practice of biting holes through the corolla." (p. 420.)

As to this latter practice —

> "The motive which impels bees to gnaw holes through the corolla seems to be the saving of time, for they lose much time in climbing into and out of large flowers, and in forcing their heads into closed ones. They were able to visit nearly twice as many flowers, as far as I could judge, of a *Stachys* and *Pentstemon* by alighting on the upper surface of the corolla and sucking through the cut holes, than by entering in the proper way. Nevertheless each bee before it has had much practice, must lose some time in making each new perforation, especially when the perforation has to be made through both calyx and corolla. This action therefore implies foresight, of which faculty we have abundant evidence in

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* H. Müller had come to the same conclusion.

their building operations; and may we not further believe that some trace of their social instinct, that is, of working for the good of other members of the community, may here likewise play a part? Many years ago I was struck with the fact that humble-bees as a general rule perforate flowers only when these grow in large numbers near together," etc., etc. (p. 433.)

It appears that the cutting of these holes is done only by humble-bees, never by hive-bees. Yet the latter are quick to take advantage of them.

"In the early part of the summer of 1857 I was led to observe during some weeks several rows of the scarlet kidney-bean (*Phaseolus multiflorus*), whilst attending to the fertilization of this plant, and daily saw humble- and hive-bees sucking at the mouths of the flowers. But one day I found several humble-bees employed in cutting holes in flower after flower; and on the next day every single hive-bee, without exception, instead of alighting on the left wing-petal and sucking the flower in the proper manner, flew straight without the least hesitation to the calyx, and sucked through the holes which had been made only the day before by the humble-bees; and they continued this habit for many following days. Mr. Belt has communicated to me (July 28th, 1874) a similar case, with the sole difference that less than half of the flowers had been perforated by the humble-bees; nevertheless, all the hive-bees gave up sucking at the mouths of the flowers and visited exclusively the bitten ones. Now how did the hive-bees find out so quickly that holes had been made? Instinct seems to be out of the question, as the plant is an exotic. The holes cannot be seen by bees whilst standing on the wing-petals, where they had always previously alighted. From the ease with which bees were deceived when the petals of *Lobelia Erinus* were cut off, it was clear that in this case they were not guided to the nectar by its smell; and it may be doubted whether they were attracted to the holes in the flowers of the Phaseolus by the odor emitted from them. Did they perceive the holes by the sense of touch in their proboscides, whilst sucking the flowers in the proper manner, and then reason that it would save them time to alight on the outside of the flowers and use the holes? This seems almost too abstruse an act of reason for bees; and it is more probable that they saw the humble-bees at work, and understanding what they were about, imitated them and took advantage of the shorter path to the nectar. Even with animals high in the scale, such as monkeys, we should be surprised at hearing that all the individuals of one species within the space of twenty-four hours understood an act performed by a distinct species, and profited by it." (pp. 430, 431.)

But we must cut short our citations and remarks; passing by one of the most important points, relative to the amount of fertilizing work done by insects, namely, the evidence of the extraordinary industry of bees and the number of flowers visited within a short time; which, as well as the distance to which pollen is sometimes transported, is far greater than one would have supposed. But the volume is reprinting by the Appletons, and will soon be within the reach of all,—along with a new edition of the orchid-fertilization book, the proper supplement to the present work, relating as it does to the class of plants in which the adaptation for fertilization by insects is carried to the highest degree of specialization and perfection.

ART. XVII.—*Note on Microdiscus speciosus*; by S. W. FORD.

IN my original description of this interesting Trilobite (this Journal, August, 1873) it is stated that the thorax is composed of four equal segments. The description, in so far as relates to this part of the animal organization, was drawn up from the study of a single specimen, showing the head, thorax and pygidium in nearly their natural positions, and apparently offering decisive testimony as to the true number of body-rings. Somewhat more than a year ago, however, I obtained from the Troy beds another specimen, of almost precisely the same dimensions, showing clearly but *three* segments in the thorax; and, subsequently, a much larger specimen showing the same number. This led me to re-examine, more critically, the specimen employed in the original description, when it was found that the head had slipped slightly forward, and that what I had regarded as the first pleura (all of the pleuræ of one side, as well as one-half of the head, being enveloped in the matrix) was a fragment of some foreign body that had fallen into the gap thus made. The deception, in the first instance, was rendered all the more complete from the fact that, by the displacement of the head alluded to, the articular fold of the first body-ring, which is ordinarily wholly hidden from view by the backward prolongation of the glabella, was exposed, thus making a very good case for a fourth segment. I now consider it certain that this species has never more than three body-rings. I have in my collection a small rolled-up specimen showing the extremities of but two body-segments, and I was at first led to think it possible that we had in this species an example of the metamorphoses of Trilobites, concerning which Barrande has taught us so much. But as I have observed since this specimen was obtained, an individual of even smaller size, with three perfectly formed body-segments, this notion is without foundation at the present time. I should here also add that the last body-ring is not, as I originally believed it to be, firmly soldered to the pygidium.

It is a remarkable fact that, under each of the four trilobitic genera represented in the Troy Primordial, viz., *Olenellus*, *Conocoryphe*, *Microdiscus* and *Agnostus*, there should be found, in this fauna, a species affording an example of a well-marked departure from the usual structure of the genus to which it belongs. Thus *Microdiscus speciosus* has but three body-rings, as already stated, while all the other described species of the genus whose thorax is known have four; *Agnostus nobilis* has but one body-ring, while nearly all of the other species have two; *Conocoryphe trilineata*, with its singularly-cleft caudal margin stands widely apart from all the other certainly known species of the genus; while *Olenellus asaphoides*, unlike the other described species in which the thorax has been observed, has none of its anterior pleuræ extravagantly prolonged as compared with the others. In this respect this latter species, as Barrande has already indicated, sustains the same relation to the Vermont forms of the genus as do the Swedish *Paradoxides* to their Bohemian allies.

November 20th, 1876.

ART. XVIII.—*On Water Courses upon Long Island;* by ELIAS LEWIS, JR.

IT has been estimated that of the forty-two inches of average annual rainfall upon Long Island more than three-fourths sinks directly into the porous soil. The excess which occurs when the fall is unusually heavy, or the surface frozen, makes its way into the innumerable valleys which traverse its surface. These valleys may therefore be considered as lines of surface drainage, the principal of which have their source on the high grounds near the center of the island, whence a portion of them extend northward toward Long Island Sound, others southward to the bay or ocean.

On the north side of the island, of which we shall first speak, many small lateral valleys open into the larger ones, cutting the surface into a series of valleys and hills, forming a landscape exceedingly beautiful and picturesque.

The high grounds referred to comprise a range of hills which extend more than sixty miles in a direction parallel with that of the island, and which vary from 150 to 384 feet in height. This range is called, absurdly enough, the backbone of the island. It consists, however, of glacial drift, with boulders, many of immense size, but is wholly without rock in place. It is upon this range, quite at the top in many instances, that the principal water courses have their source. From these elevations they extend as broad deep valleys, well cultivated or wooded, rarely presenting evidence of recent erosion.

An inquiry is suggested, how and when were they formed? The surface waste of water from the present volume of rainfall seems wholly inadequate to produce them. Much of this percolates the soil after reaching the valleys, and in many instances the bottom of the valleys, which is usually of gravels and sand, is covered deeply by an accumulation of sedimentary matter because the flow of water through them has not been sufficient to maintain them at their original depth. In the great watercourse which opens at Glen Cove there occurs, three miles southward from its termination, a deposit of fine clay six feet or more in thickness, and thirty feet below accumulated sediment in the valley. The fact that such deposits occur in the old water courses suggests, we think, feeble energy of erosion, and points to a time when it was more active than now.

The formation and maintenance of a valley implies that the material which filled it, or which might have filled it, has been removed by a stream of sufficient volume to accomplish the work. A quantity of rainfall is conceivable which would erode and deepen the valleys in question, and that such occured at a former period is quite possible, but we insist that while some erosion must occur when water moves over the surface of the ground, that the great development of these valleys, especially at their source, and upon the highest grounds, is not explained by the present surface waste. The watershed of the island upon the hills is narrow; frequently a few rods, or feet separates the source of a valley extending northward from one running southward.

We are inclined to look to an agent other than rainfall for the development of the surface sculpture of Long Island. Excepting its lower beds which may consist of Tertiary or Cretaceous deposits, or of both, the island is a glacial moraine,—a mass of debris both unmodified, and in every stage and form of modification. The surface valleys were evidently watercourses for sub-glacial streams supplied by the ever wasting ice while it still lay upon the coast. From this cause a deep erosion of the highest grounds was possible, and the general contour of the surface determined. The direction and course of all the principal valleys indicate their common origin. So deeply marked and well defined are they that little change in their general aspect seems to have taken place since the disappearance of the ice sheet from the coast. If from the surface valleys we turn to the similar but vastly greater ones on the north side of the island which now constitute the series of magnificent harbors upon its coast, we find proof that they too had their origin in glacial times. These harbors are eight in number, and although in glacial drift are as truly fiords as those along the rocky coast of Greenland. They extend into the island from three to six miles, they are from half a mile to a mile and a half broad and are in the deeper portions from ten to twenty-five feet deep. They were probably deeper when free from sediment. In a few instances where tidal currents are strong the water is from thirty to fifty feet deep. The land on either side of the fiords is from a few feet to as much as 200 feet above tide, and the valleys continue long distances inland beyond where the tides reach. Many lateral valleys open into these, evidently cut by glacial streams. It is extremely probable that these great fiords were, at an early stage of the formation of the island, water-courses opening to the ocean, and were maintained as such until filled by accumulating drift. This may have occurred while the ice sheet still lay over the region, and the streams were under or sub-glacial ones. When however the valleys were finally filled with drift at their terminus the waters were arrested, and thenceforth discharged eastward and westward through, what is now, Long Island Sound.

There is no evidence that the fiord valleys have changed in their general contour since the glaciers disappeared. The facts undoubtedly imply that the coast stood at a greater elevation than now, for the glacial-fed streams must have swept the fiord valleys to their bottom. But Prof. Dana has shown long since that the Glacial period was probably one of elevation of Northern lands.

There is reason for the conclusion, however, that some deepening of the principal surface valleys has taken place subsequently to the disappearance of the ice, which may be attributed to streams. There occurs in many instances fragmental deposits of sand and gravel along their banks, ten to twenty or more feet above the bottom, which seem to be remains of flood plains, and indicate erosion to that extent. If this be correct, a more abundant rainfall at a former period is suggested, and it may have occurred while the ice still lay upon New England. Chilled by its presence the vapor-laden air from the ocean might have dropped its moisture in more abundant rain or snow upon the coast, and local accumulation of snow upon the hills during winter may have aided in swelling the eroding streams.

The water-courses which open southward from the central hills of the island extend over a nearly uniform plain; they are of moderate depth, rarely greater than twenty feet, have few tributaries, and are quite direct and continuous from the hills to the bay. They are over a formation geologically different from that on the north side of the hills, it being stratified gravel and sand, proving the presence of the ocean over the region subsequent to the deposit of the drift. The stratified beds occur at all heights up to 260 feet above tide, and imply a submergence of the coast to that extent. There still remained, however, many elevations above the ocean (or if they were submerged their contour was not altered), for they now show the same development of old valleys as we have noticed on the north side of the hills. This is important in explaining the newer valleys over the stratified, and newer beds. We have traced several of these to their source, and find that in each instance the new valley is a continuation of an old one. These new valleys are called locally "plain valleys," because they traverse the plains, and there are thirty of them between East New York and Riverhead, a distance of fifty miles.

It is easy to see why the new valleys are continuous with those upon the higher grounds, as the precipitation upon the region would flow into the old valleys, giving direction to the surface waste in streams. These at the period of submergence, which was probably the closing of the Glacial, or opening of the Champlain period, would continually empty into the bay or ocean near. As the coast arose from the water the shore line receded, but the streams would still reach it, and slowly but surely erode the plain valleys in question. It thus appears that the water courses over the modified drift of the plains have their origin in older valleys worn by glacial torrents in a preceding age.

There is a source of valley erosion on both sides of Long Island which has not yet been mentioned. It arises from springs fed from rainfall, which break out and flow during the whole, or part of the year in some of the valleys. These springs are from under-drainage. On the south side of the island they appear from one to three miles from the coast, forming streams of great beauty and purity. It is from this source that the city of Brooklyn is supplied with its wonderfully pure water. There is reason to conclude that the springs broke out farther inland at a former period. On the north side of the island springs appear in some of the valleys from which small streams flow a part of the year. In both instances, however, we should not expect the cropping out of springs, in valleys, until the valleys were formed. It is because, in most instances, the valleys have been cut down, to the level of saturation, that springs appear, and if at any period they cropped out farther inland in the valleys, or upon a higher level, it was because the level of saturation was higher than it now is. Any subsequent lowering of it has arisen from a diminished supply of water, consequent upon diminished precipitation.

In review the following conclusions seem to be sustained:—

1. The formation of the principal valleys about the hills of central Long Island and northward to the Sound was concurrent with the closing period of the ice over the region, but some deepening has taken place by water from rainfall, both from its surface waste, and from under-drainage, forming springs in some of the valleys.

2. The great fiord valleys were contemporaneous with the progress of the ice period.

3. The "plain valleys" have been formed by streams from both surface and under-drainage, and originated in older valleys which determined the flow of the eroding waters.

4. A further conclusion is suggested that the volume of precipitation over the region was greater at a former period than at the present time.

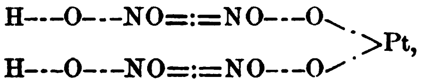
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Purification of Hydrogen gas.*—Although the use of hydrogen gas as a reducing agent in analytical operations has become quite general since it was proposed by Rose, yet no method of perfectly purifying this gas has been described. Schobig has made a series of experiments upon the use of a saturated solution of potassium permanganate for this purpose, the results of which appear to be quite satisfactory. The impurities which were introduced were the hydrogen compounds of sulphur, phosphorus, arsenic, antimony and carbon. The permanganate was used as neutral, acid, and alkaline solution, contained in a Bunsen wash-bottle. Careful examination of the gas after passing through a layer 10 cm. thick of the solution, either when only a single impurity was present or when all were mixed together, failed to show a trace of foreign substance. Hydrogen sulphide was found to be best removed by an alkaline solution; the other substances by a neutral or acid one. Even coal gas after passing slowly through a thickness of ten centimeters of the solution, deposited no carbon when passed through an ignited tube, the carbon being oxidized to carbon dioxide. As to the question whether hydrogen itself is not oxidized by the permanganate, the author made comparative experiments with neutral, acid and alkaline solutions, which showed that oxidation does take place, the maximum rate being about a third of a cubic centimeter per hour under the conditions employed, and this in the neutral solution. With the hydrogen thus perfectly purified the author succeeded in reducing a silver solution, in the dark and in the absence of organic matter. In dilute solutions the silver separated as a fine powder; in concentrated ones, it formed a mirror.—*J. pr. Ch.*, II, xiv, 289, Oct., 1876. G. F. B.

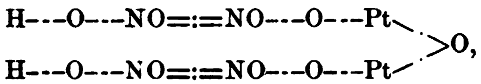
2. *On Hypovanadic Oxide and its Compounds.*—CROW has examined, under Roscoe's direction, the modes of production and the properties of the hypovanadic oxide of Berzelius (vanadium tetroxide) and some of its compounds, the vanadium being determined analytically either by titrition with permanganate or by fusing and weighing as pentoxide. Hypovanadic oxide, prepared by heating the chloride to redness in an atmosphere of carbon dioxide, is nearly pure, containing about 95 per cent of V_2O_4. It is a dark-green amorphous powder, insoluble in water, soluble in acids or alkalies, and absorbs oxygen from the air. The hydrate, obtained by precipitating a solution of the sulphate or chloride with sodium carbonate, filtering in an atmosphere of carbon dioxide and drying in a vacuum, is a black amorphous mass, having the composition $V_2O_4, (H_2O)_7$. Two trisulphates are described, one with seven, the other with four molecules of water, both of which are light blue deliquescent crystalline powders. Two similar disulphates were also obtained. The chloride, $V_2O_4Cl_2, (H_2O)_5$, prepared by dissolving the pentoxide in hydrochloric acid, reducing the solution with hydrogen sulphide, and evaporating, is a brown amorphous deliquescent mass, which yields a blue solution. Potassium hypovanadate, $K_2O.(V_2O_4)_2, (H_2O)_7$, is deposited in reddish-brown crystalline scales or needle-shaped crystals, when the sulphate or chloride is treated with excess of potassium hydrate and allowed to stand, closely stoppered, some hours. The sodium salt is similar. The ammonium, barium, lead and silver salts, the last two of which are anhydrous, are also described as brown or black precipitates.—*J. Chem. Soc.*, xxx, 453, Nov., 1876. G. F. B.

3. *On Plato- and Diplato-nitrites.*—NILSON has examined at length the peculiar double nitrites of platinous oxide and potassium, sodium, ammonium, silver, mercury and barium described by Lang, and, adopting Blomstrand's view that they are paired compounds of quinquivalent nitrogen, he considers them to contain the bivalent radical platotetranitrosyl, the acid from it,



$$\left.\begin{array}{l}\text{H---O---NO=:=NO---O}\\ \text{H---O---NO=:=NO---O}\end{array}\right>\text{Pt},$$

being called platotetranitrosylic acid or platonitrosylic acid, and the salts platonitrites. He describes also new compounds containing another similar radical, in which, to the four nitrosyl groups, there are two platinum atoms and one more atom of oxygen. This radical he calls diplatotetranitrosyl, the free acid,



$$\left.\begin{array}{l}\text{H---O---NO=:=NO---O---Pt}\\ \text{H---O---NO=:=NO---O---Pt}\end{array}\right>\text{O},$$

being diplatonitrosylic acid and the salts diplatonitrites. Nilson has prepared the potassium, rubidium, cæsium, ammonium, thallium, sodium, lithium, silver, calcium, strontium, barium, lead, magnesium, manganous, cobaltous, nickelous, ferrous, cupric, zinc, cadmium, mercurous, aluminum, yttrium, erbium, cerium, lanthanum and didymium platonitrites, and silver, glucinum, aluminum, chromous, indium and ferric diplatonitrites. The former salts are for the most part beautifully crystallized, though the solution must be concentrated, since they are very soluble in water. The diplatonitrites, with the exception of the silver salt, which is green, are characterized by their brilliant red color.—*Ber. Berl. Chem. Ges.*, ix, 1722, Dec. 1876. G. F. B.

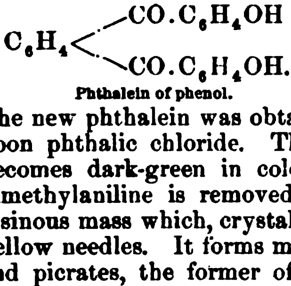
4. *On the behavior of Palladium in the Alcohol flame.*—Wöhler, as early as 1824, having observed that palladium, either in the form of foil or sponge, when heated in an alcohol flame covered itself with a thick layer of carbon, rendering the metal porous and brittle, and having, upon Graham's discovery of the remarkable occlusion of hydrogen by this metal, assumed this as the cause of the phenomenon observed by him, has now sought to verify the supposition by passing pure dry ethylene gas over palladium sponge, first at 100°, then at higher temperatures; but no result was obtained until a red heat was reached, when carbon was deposited and hydrogen evolved; the temperature being below that, however, at which ethylene itself decomposes. Since palladium has no affinity for carbon, the author suggests that the result observed may be due to an alternate union with hydrogen and separation therefrom. He also describes a convenient apparatus for showing the absorption of hydrogen by palladium and its evolution on heating.—*Ber. Berl. Chem. Ges.*, ix, 1713, Dec. 1876. G. F. B.

5. *On two new Dichlornaphthalenes.*—The α and β varieties of dichlornaphthalene, described by Faust and Saame, have fusing points of 35–36° and of 68° respectively; the γ variety, obtained by Atterberg, fuses at 107°. Cleve has prepared two new forms of this substance, δ-dichlornaphthalene, fusing at 114°, and ϵ-dichlornaphthalene, fusing at 135°, by the action of phosphoric chloride upon the calcium salts of the two napthalene-disulphonic acids described by Ebert and Merz. The former body is easily soluble in boiling alcohol, from which it crystallizes in broad brilliant plates. The latter is much less soluble and crystallizes in brilliant prisms.—*Bull. Soc. Ch.*, II, xxvi, 244, Oct. 1876. G. F. B.

6. *Emodin from the bark of Rhamnus frangula.*—Liebermann and Waldstein have examined the crystallized substance contained in the bark of *Rhamnus frangula* (buckthorn) with a view to ascertain the relation of the frangulinic acid of Faust, which he had recognized as an anthracene derivative, to the other isomers of alizarin. The crude material was obtained from Merck, and was prepared by extracting the bark with dilute soda solution, precipitating with hydrochloric acid, and after repeating this process, recrystallizing from alcohol. It was a red crystalline powder containing small quantities of some glucoside. Purified by recrystallization from glacial acetic acid, it gave beautiful orange silky needles, which after sublimation and crystallization

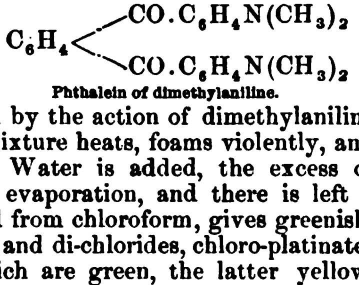
from absolute alcohol gave on analysis the formula $C_{15}H_{10}O_5$, which is that also of emodin, obtained from rhubarb root, as Liebermann had shown. The acetyl-derivative was prepared, and found to be acetyl-emodin. The hydrocarbon obtained by distilling it with zinc dust, was a mixture of anthracene with methyl-anthracene, as its oxidation products showed. A close comparison proved the substance to be identical with emodin. The bark contains only about 0·2 per cent of it. Whether frangulinic acid also actually exists in the bark, the authors promise further investigation to determine.—*Ber. Berl. Chem. Ges.*, ix, 1775, Dec. 1876. G. F. B.

7. *On the Phthaleins of tertiary aromatic Bases.*—The remarkable analogy between dimethylaniline and phenol, shown in the production by Michler of a new body from the former by a reaction similar to the synthesis by Kolbe of salicylic acid from the latter, has led **Fischer** to follow up this analogy and to produce a phthalein of dimethylaniline corresponding exactly with the phthalein of phenol, one of Baeyer's remarkable bodies. This resemblance is clearly shown in the following formulas of these substances:



$$C_6H_4{<}\begin{array}{l}CO.C_6H_4OH\\CO.C_6H_4OH.\end{array}$$

Phthalein of phenol.



$$C_6H_4{<}\begin{array}{l}CO.C_6H_4N(CH_3)_2\\CO.C_6H_4N(CH_3)_2\end{array}$$

Phthalein of dimethylaniline.

The new phthalein was obtained by the action of dimethylaniline upon phthalic chloride. The mixture heats, foams violently, and becomes dark-green in color. Water is added, the excess of dimethylaniline is removed by evaporation, and there is left a resinous mass which, crystallized from chloroform, gives greenish-yellow needles. It forms mono- and di-chlorides, chloro-platinates and picrates, the former of which are green, the latter yellow. Reduced with zinc dust, it gives a colorless base, like the phthaleins of the phenols.—*Ber. Berl. Chem. Ges.*, ix, 1753, Dec. 1876.

G. F. B.

8. *Standard Meter.*—M. G. **Matthey** presented to the French Academy at their meeting of Dec. 4th the platinum-iridium 4-meter bar, constructed for the International Geodetic Association. The metals were prepared by MM. Sainte-Claire Deville and Debray, and each time 450 ounces of platinum and 55 (50 ?) ounces of iridium were used. Five ingots thus prepared were cut in small pieces by a hydraulic press. The fragments were then melted in the same furnace and kept in a liquid state for a long time by a flame of oxygen and burning gas. The new ingot was forged and then rolled. The faces of the hammer and anvil were of polished steel constantly rubbed. The sheets after being well scraped were again melted in a rectangular furnace and produced a very homogeneous mass free from cracks or roughness on the bottom, sides or top. After the first forging a bar was obtained 35 cms. long, 7·5 cms. wide and 2·5 cms. thick, which weighed 15·105 kgs. and had a specific gravity of 21·522. A third of the

bar was cut off and the other two-thirds when forged and well annealed had the following dimensions: Length, 95 cms.; breadth, 2·5 cms.; thickness, 2 cms. Its weight was then 10·315 kgs. and its specific gravity, 21·648. The bar was next rolled between polished cylinders and brought to very nearly the required dimensions, of length 410 cms., breadth 2·1 cms., and thickness ·5 cms. Finally, a perfectly rectangular form was given to the bar by drawing it several times through a hole in a plate of steel. Each time the bar was heated to the highest temperature by a very large gas blowpipe fed with oxygen, and it was passed through the same hole until a force was no longer required to draw it through and it no longer underwent a sensible elongation. Each time when hammered, rolled or drawn, the metal, heated either in a great muffle or by the blowpipe, was cleaned by melted borax and by concentrated chlorhydric acid. The rule ought to receive from the makers, MM. Brünner, the high degree of polish of which it is susceptible, and which in its present rough condition it does not possess.

M. Deville in commenting on this communication gave the following result of an analysis of a portion of this alloy: Platinum, 89·42; iridium, 10·22; rhodium, ·16; ruthenium, ·10; iron, ·06; total, 99·96. The density computed from that of these components was 21·515; that observed, 21·516. A second analysis gave by computation 21·51; by observation, 21·508. He then exhibited two tubes of the same alloy made from the portion cut off from the bar as described above. These tubes are closed by spherical cups, of which one terminates in a capillary tube which enables the interior to be put in communication with Regnault's manometer. Each of these tubes is more than a meter long and one of them has a capacity of over a liter. This is to serve as an air thermometer for the determination of the boiling points of various liquids under known pressures. These tubes will have on their surfaces two lines a meter apart. The deviation compared with that of the second tube which will be kept in ice, will enable the exact temperature to be calculated. This will carry out a suggestion long since made by Regnault, and which has been applied to the measurement of high temperatures. It will be interesting to apply this method to the measurement of the lowest temperatures so far attained. These researches have an important bearing on metrology. All substances capable of being tempered, as glass and steel, undergo a change with time. Others which like zinc crystallize with changes of temperature also change with time. Hyaline quartz, according to Mr. Wild, appears exempt from this change. Does the platinum-iridium act like steel, zinc or quartz? This question will be solved by weighing the quantity of water which one of these tubes will contain at 0°. After all the experiments in which the temperature will be varied between very wide limits the capacity of the tube will be again measured. Each change of three milligrams in the weight of the meter will represent the volume of the tube corresponding to a change of one-thousandths of a millimeter in the distance between the two lines marked on the tube.—*Comptes Rendus*, lxxxiii, 1090. E. C. P.

9. *Films of Water.*—Mr. TYLOR read a paper before the London Physical Society on the cohesion and capillary action of films of water under various conditions. The author endeavors to eliminate the action of all forces except that of gravity by immersing his "valves" in water. The models which he exhibited consisted of glass tubes about three inches in diameter and six inches high, filled with water and containing each a piston, which, on being raised, was capable of lifting by cohesion a heavy mass of metal, the nature of the surfaces in contact differing in the several instruments. From experiments with them he concludes that the time during which a heavy valve can be supported depends upon the size of the surface of contact, the difference of pressure within and without the moving parts, and the smoothness of the valve. On the contrary, dry bodies, such as Whitworth's surface planes, will adhere for an indefinite period. Mr. Tylor considers that the supporting of a body in water is due to a difference of pressure in the water itself, and he adduced Giffard's injector as showing that such differences can take place. He has also studied the form of a drop of water at a tap, and considers that when a fly walks on a ceiling its weight acts in the same manner as the heavy valves in the models exhibited.—*Nature*, xv, 131. E. C. P.

10. *Fog-Signals.*—Prof. HENRY at the recent meeting of the United States National Academy communicated some additional facts obtained in his long-continued and elaborate researches concerning sound in relation to fog-signals. His principal investigation this year had reference to the divergence of sound, especially as to the phenomenon known as the Ocean Echo. To test the explanation given by Prof. Tyndall, requiring reflection from the air, the trumpet of a siren was turned directly to the zenith. The blast was exceedingly intense, but no echo was heard from the prolongation of the axis of the trumpet, i. e., from the zenith. A loud echo was, however, heard from the whole circumference of the horizon, half of which was on land, the other half on water. This was repeated many times, and always with the same result. In one case a small cloud passed directly across the zenith, from which a few drops of rain fell into the mouth of the trumpet; still no sound was heard from the zenith, although sound continued to be heard from around the horizon. In this case on account of the divergence of the sound, portions of waves in every direction must have descended to the horizon, and as some of these must have reached the plane of the ocean in a path curving inward toward the source of sound, they would, when they reached the ear of the observer in the vicinity of the source, seem as if coming from a point in the horizon, and hence would give rise to the phenomenon of the ocean echo. Rays of sound at different distances from the ear could be reflected from the surface of the ocean and thus give rise to a prolonged echo. This is in

accordance with the fact observed during last summer, that a blast of five seconds' duration gave an echo that was prolonged twenty seconds. This could only be produced by ordinary reflection from a series of surfaces placed at different distances, an arrangement of the material of the atmosphere which (on the doctrine of probabilities) would not be of frequent occurrence.—*Nature*, xv, 129. E. C. P.

11. *The Siphon Recorder and Automatic Curb Sender.*—An illustrated article showing the practical as well as the theoretical construction of these instruments appears in *Nature* for Nov. 30th, 1876 (xv, 101). For some time after the introduction of submarine telegraphy the mirror galvanometer was the only instrument delicate enough to receive the messages transmitted through a long cable. The clerks must here read the message by watching the deviations of a spot of light from side to side. The siphon-recorder serves to draw a sinuous line by which the message is recorded in permanent form. The speed of sending will be greatly increased by sending after each current a second in the opposite direction. This is effected by the curb-sender. Three rows of holes are punched in a long strip of paper, the central row serving to carry the paper through the machine and the row on one side corresponding to the dots or positive currents, that on the other to the lines, or negative currents. When the paper passes through the machine it receives by clock-work a uniform motion. Two prickers are placed so as to correspond to the two outer rows of holes. When a hole passes, the corresponding pricker falls into it, and in so doing lifts a spring through an opening in the rim of a revolving wheel. The spring being caught in the rim of the wheel is obliged to remain there until the wheel makes one complete revolution and the opening in the rim returns to free it. The wheel makes one revolution while one space passes the pricker. When the spring is lifted into the rim of the wheel it makes connection between the battery and another set of springs, by which a current is sent through the cable, and shortly after it a second current is sent in the opposite direction. The currents are reversed when the other pricker acts. E. C. P.

II. GEOLOGY AND MINERALOGY.

1. *Report on the Transportation route along the Wisconsin and Fox Rivers in the State of Wisconsin, between the Mississippi River and Lake Michigan;* by GOUVERNEUR K. WARREN, Major of Engineers and Brevet Major General, U. S. Army. 114 pp. 8vo, with many maps. Senate Ex. Document, No. 28, 44th Congress. Washington, 1876.—General Warren's Report gives, first, a history of geographical knowledge and surveys respecting this old transportation route, then an account of the work that has been done by him or under his direction. We take the following facts from it.

The two streams—the Fox River which joins Lake Michigan at the head of Green Bay, and the Wisconsin, which empties into the Mississippi at Prairie du Chien, come within a mile and a half of one another, at bends in each, near Portage City, where a granite ridge lies near the surface. The summit of this Portage region is about 218 feet above Lake Michigan, and 188 above the Mississippi, and the summit of this water level 208½ and 178½ feet. The stream from Portage eastward (Fox River) passes through Lake Winnebago (besides three smaller lakes), with a descent of 39 feet, and then plunges down the remaining 169½ feet along a limestone gorge whose sides are fifty feet or less in height.

The region of Lake Winnebago is bordered on the west by a low alluvial plain, partly marshy, which is represented on a map as reaching thirty miles west, and then extending in broad areas both north along Wolf River, and southwest along the Upper Fox toward Portage, and hence as including the other small lakes of the route. General Warren explains the origin of these features on the view that the whole alluvial area was originally a lake; at which time the waters drained off over the low granite ridge at Portage through the Wisconsin River to the Mississippi.

The height of this divide now existing at Portage is only a few feet, so that the westward flow would have necessarily taken place were the waters at the height required to make the lake. Afterward there was a subsidence to the northeastward which determined the flow in that direction (where the loose material easily gave way, while granite resisted wear in the opposite course) down the limestone slope, toward Green Bay, making thus the Lower Fox River channel. That this subsidence occurred after the Glacial period is stated to be shown by the absence of glacial drift from the alluvial plain.

The facts are of the highest interest because they tend to prove that the subsidence of the Champlain period (that following the Glacial), so well sustained for the eastern part of the Continent, in its higher latitudes, by facts along the coast of New England, Labrador, and regions farther north, and also on the shores of Lake Champlain and the St. Lawrence, actually affected also the interior of the Continent, for which it is so difficult to find evidences of change of level.

General Warren obtained the same proofs of a northward sinking, for the Champlain period, in the region between the Upper Mississippi and Lake Winnipeg. (See his Memoir on the Valley of the Minnesota.) He showed, by the facts, that Lake Winnipeg had once had a very great expansion and then had discharged southward by Minnesota River valley; but that afterward, subsequent to the Glacial period, a change of level in the land had taken place by a subsidence to the northward, or a subsidence that was relatively greatest in that direction, which turned their course into the present outlet toward Hudson's Bay.

In addition, General Warren observed that the southward discharge of Lake Winnipeg must have been determined by a previous rising of the land to the north (as referred to in a notice of his report in this Journal, vol. ix, p. 313); thus sustaining the idea of an elevation of the interior of the Continent at the opening of the Glacial period, and an elevation which was greatest to the north. These conclusions—an elevation increasing in amount northward, followed after the Glacial period by a subsidence increasing northward—were reached without reference to any preconceived hypothesis.

Sand-bars.—Gen. Warren also describes with detail the form and structure of the sand-bars in the Wisconsin River, giving facts that are of general geological interest. The surface of these bars has a gradual pitch up stream, and a steep front down stream—as in a ripple mark. The sands are dropped where there is still water along the shores, but the larger part in the still water on the down-stream edge of the bars, thus building up this edge toward the water's surface. The sand, where the current is strong, "is moved along the gentle slope of the upper side till the crest is reached, when it falls over and stops in the still water below." The bar thus grows and becomes more convex in its down-stream outline. Such sand-bars have a channel of deep water either side, and also tend to make, by acting as a dam at the low-water stage of the stream, large areas of deep still water above them. The changes in the current produced by the growth of the bars and the greater changes from change of level in the river by floods, produces frequent changes in the bars, so that they are not the same in position from year to year. At very low water, the bars may be mostly dry, with winding narrow channels of water among them. This tends to improve the navigation for the time; but a rise, if small and temporary, sends the water across these channels and fills them up.

The sand-bars made in the Mississippi by the discharge of the Wisconsin are of great extent. Besides pushing the deep water channel to the west shore, they act as a dam and make an area of relatively still water above, thus causing good navigation above the junction and bad below—a common fact at junctions in the rivers of the Mississippi basin. The Wisconsin River flows from a region of much less summer rain than the Mississippi, and is often at low-water stage when the latter is high; and hence it is made very shoal by sand-bars formed in its mouth.

The sands of the Wisconsin River bars are almost purely siliceous, and come from the drift deposits bordering its course. The specific gravity, "excluding voids," of two specimens from different parts was 2·6392 and 2·6667. For comparison the specific gravity of other sands was obtained, as follows: at St. Paul, Minnesota, on the Mississippi, 2·6397; at Rock Island, Illinois, 2·6166; at Saybrook Bar, mouth of Connecticut River, 2·6406; at Block Island, R. I., 2·6392; at Newport, R. I., 2·6563. The Report also compares different sands as to proportional fineness, giving the proportion that passed through sieves of different grades; and, also, as to the changes in volume in different sands due to wetting when loose and packed. The loose sands of the Wisconsin River shrink in volume ·0146, and ·0197 (two specimens); while that of Saint Paul shrinks ·0695; that of Block Island, R. I., ·0788, and that of Newport, R. I., ·1352. These investigations of different sands were made in order to ascertain the reason why the Wisconsin sands are "easily moved"

2. *Ice work now going on in Newfoundland.*—Mr. S. MILNE gives many valuable facts on modern ice-work in Newfoundland in a paper in the Geological Magazine for September last, from which the following are here cited.

Ice forms on the shores from the spray and occasional snows, enveloping and thus grasping firmly the stones and bowlders beneath, and attaining considerable thickness; and when a northern pack strikes it, it is pushed up shore, sometimes to a distance of a hundred yards. In the movement the rocky surfaces beneath are polished and scratched in a style precisely like the work of glaciers. The breaking away of the pack near the water line leaves the stranded ice with a thick front called by the fishermen a *balacada*, a corruption probably of *baracada* of the Spanish. This shore ice, with its cargo of bowlders, stones and gravel, is often drifted off as the tide rises, and especially when a land breeze favors; and great lines of bowlders off the shore are thus made. In the same way the cables and anchors left on the shore have sometimes been carried off,—to the regret of the fishermen.

The blows made by the coast-ice when driven up the land, or by the floating ice when pushed ashore, have immense power and do great execution on the rocky bluffs. Scoresby's calculation, that the blow produced by one of the immense ice-fields is equal to that of 10,000,000,000 tons, affords an idea of the force of the impact in many cases, and aids us in realizing the greatness of the work of coast degradation carried on in every cold season by the reiterated strokes.

3. *The Glaciation of the Shetland Isles.*—In the Geological Magazine for May and June, 1870, my colleague, Dr. Croll, first pointed out that the Scotch and Scandinavian ice-sheets probably united on the floor of the North Sea, and thence moved westward toward the Atlantic. He was led to this conclusion by a consideration of the peculiar direction of the striæ in Caithness, in Shetland, and the Faroe Isles, as well as by the occurrence of marine shells in the bowlder clay of the northern parts of Caithness. He showed that the enormous *mer de glace* which pressed out on all sides from Scandinavia forced its way close to the Scotch coast-line, and in virtue of its greater size produced a slight deflection of the Scotch ice, causing it to over-ride portions of the main land. He stated that in all likelihood both the Shetland and the Faroe Isles were over-topped by the Scandinavian ice in its onward march toward the Atlantic.

During a recent traverse in Shetland I obtained evidence which tends to strengthen this remarkable theory. In the north island of Unst, the direction of the striæ, the bowlders on the surface, and the stones in the till, clearly indicate that this island was glaciated by a mass of ice moving from east to west. The proofs of continental glaciation, which are comparatively clear in the north, are obscured in a great measure in the main island by the effects of a local ice-sheet. The nature of the bowlder clay, as well as the trend of the striæ in various localities, show that the movement of this local sheet was influenced by the general features of the country. In addition to these markings, however, others were found which could not have been produced by ice shedding off the land in the ordinary way. These cross the island, regardless of its physical features, and are often at right angles to the newer set. Lastly, the wide distribution of morainic matter with groups of moraines indicate the gradual disappearance of the local ice-sheet and the presence of small glaciers, where the ground presented favorable conditions for their development.

The islands are dotted over with small lochs; the most of these lie in peat or drift, while others occupy true rock basins. The singular absence of marine terraces ought not to escape notice, as bearing on the recent geological history of these islands, since the voes or sea-lochs are admirably adapted for their preservation.

These observations will be described in detail in a forthcoming paper before the Geological Society. JOHN HORNE.
—*Nature*, Dec. 14, 1876.

4. *Note on the relations of Balanus Estrellanus of the California Miocene;* by T. A. CONRAD. (From a letter to J. D. Dana, dated Philadelphia, Dec. 4, 1876.)—Some time ago I wrote you for your opinion of the propriety of classing *Balanus Estrellanus* (*Tamiosoma gregaria*) with the *Rudistæ*. It seemed so strange to me, that a member of the *Rudistæ* should be in Miocene strata, that I have recently studied its characters anew, and find it to be a true *Balanus*, and I think you will agree with me, if you consult the figure and description of *B. lævis* figured in Darwin's Monograph, pl. 4, fig. 2. In that figure the basis exhibits septa of the precise character of *B. Estrellanus;* besides, the loss of the basis shows the same structure as other Balani, but the opercular valves are not preserved. Mr. Gabb fully agrees with my determination.

I have also had occasion to restrict the number of genera which were supposed to be common to Cretaceous and Eocene strata. Thus I eliminate the genus *Cucullæa* from the Cretaceous fauna, it being represented by *Idonearca.* I think also that *Trigonia* died out at the close of the Cretaceous; for, of the many species known, none had ribs radiating from the beak, like a *Cardium*, and being unknown in Eocene strata; when the allied genus appears in the Miocene and recent fauna it assumes the radiated structure. I also exclude from the Cretaceous fossils the following genera of Veneridæ: *Callista*, *Caryatus*, *Dione*, *Grateloupea*, *Cryptogramma*, *Circe*, *Dosenia*, *Mercenaria*, *Venus*, etc., retaining only *Aphrodina*, *Cyclothyris*, *Baroda*, and *Dosiniopsis*. Some genera, as *Cardium*, *Pecten*, *Radula*, *Ostrea*, *Anomia*, *Spondylus*, *Axinæa*, *Turritella*, etc., were continued from Cretaceous strata to the recent period, but I have not yet made out a list of all the extinct genera. As it is interesting to note the occurrence of corresponding extinct genera in America and India of the same Cretaceous horizon, I would remark that in Stoliczka's Paleontology of Southern India, figs. 1 to 5, pl. vi, represent the genus *Cyclothyris*, though referred to *Cyclameria* by Stoliczka; and figs. 17–19 (*Cytheria* Stol.) belong to *Aphrodina* Con. Both of these genera are common in North Carolina.

5. *Stromatopora.*—In the number of the Annals and Magazine of Natural History for January, *Stromatopora concentrica* is pronounced a Sponge in a paper on a new genus of Cretaceous Hexactinellid Sponges, by W. J. Sollas. A second paper, by H. J. Carter, treats of the close relationship of *Hydractinia*, *Parkeria*, and *Stromatopora*, thus making the genus, or part of it, Hydroid in its relations, and so removing it far from the Protozoans.

6. *Geological Survey of Victoria. Report of Progress*, by R. BROUGH SMYTH.—The most important Report in this volume is a long one on the Devonian rocks of North Gippsland, by A. W. Howitt.

7. *Fossil Elephant in Washington Territory;* by WM. O. MATZGER. (From a letter dated Daytown, Washington Territory, July 8, 1876.)—The bones include a pelvis, jaw bone, tusk, and others. The pelvis measures 5 feet 10 inches across its widest part, and the tusk is 10 feet long. The jaw bone is two feet wide, and has one tooth on a side, measuring at top ten inches by three. The discoverer thinks that he has found portions of at least five individuals.

8. *Mesozoic Fossils*, Vol. I; Geological Survey of Canada. Part I. *On some Invertebrates from the coal-bearing rocks of the Queen Charlotte Islands*, collected by J. RICHARDSON in 1872; by J. F. WHITEAVES. 92 pp. 8vo, with 10 plates of fossils, and a map.—The Queen Charlotte Islands lie just to the north of Vancouver Island. The fossils are in general too imperfect for satisfactory identification. They include a large proportion of species of the Ammonite family. They have some Oölitic affinities, while "at least one or two are known to be Cretaceous," and indicate a relation in the beds rather to the Shasta Group (Lower Cretaceous) of California and of British Columbia, than to the Cretaceous of Vancouver, or the Chico group of California. No Vancouver species is found among them. They may belong just below the Cretaceous. Out of the 42 species of Mollusks, three—*Ammonites Breweri*, *A. Stoliczkanus* and *Aucella Piochii*, are well-known California Cretaceous fossils.

9. *Miocene in Southern New Guinea.*—Mr. C. S. WILKINSON, of the Geological Survey of New South Wales, after an examination of specimens obtained in New Guinea by William MacLeay, Esq., announces the occurrence of Calcareous clays and other beds from Hall's Sound, which are of the *Lower Miocene*,—a fact of much interest since no marine Tertiary beds have yet been reported from Eastern Australia, while they are found in Victoria

and South Australia. Professor M'Coy, as Mr. Wilkinson states, has shown that the Miocene fossils of Southern Australia were closely related generically, and even specifically to those of many parts of Europe and America. The New Guinea species are mostly identical with those of Victoria. They include *Voluta anti-cingulata*, species of *Ostrea*, *Cytheræa*, *Crarsatella*, *Pecten*, *Turritella*, *Astarte*, *Corbula*, *Leda*, *Venus*, *Cypræa*, and other genera. Mr. Wilkinson makes the following concluding observations:

The discovery of these Miocene beds on the southern coast of New Guinea is one of considerable importance. Their occurrence, I believe, suggests the former land-connection of New Guinea with the Australian continent, and this belief is further borne out by the fact of the shallowness of the intervening sea.

From geological data it is believed that this continent [Australia] has not been submerged to any great extent, since the Lower Pliocene period; and we know that it has risen a little since the Upper Pliocene epoch, at least in Victoria, for the lava flows of that age, now forming the Werribee Plains, were *submarine* flows. And Mr. Daintree, formerly government geologist of Queensland, shows, in his pamphlet on the Geology of Queensland, that little upheaval of this portion of Australia has taken place since the volcanic outbursts of a late Tertiary epoch. Now, it is in the Upper Pliocene or Pleistocene deposits [or Quaternary] that are found the remains of the gigantic marsupials—*Diprotodon*, *Macropus titan*, *Nototherium*, and others; and, as their allied representatives now occupy both Australia and New Guinea, it is not improbable that those gigantic animals, whose bones are found in Northern Queensland, also roamed in both those countries. And farther, as the luxuriant vegetation and climatic conditions which we suppose to be favorable for the support of those immense marsupials, still exist in New Guinea, is it rash to conjecture that some of these large creatures may not be living there at the present time? Farther researches may prove this.

10. *Recherches sur les Fossiles Paléozoiques de la Nouvelle Galles du Sud* (Australie); par L.-G. DE KONINCK, D.M. 140 pp. 8vo, with at atlas in 4to. Bruxelles. 1876. (Mem. Soc. Roy. des Sci. de Liege.)—This paper contains descriptions and figures of many Australian species, and of them a considerable number are identical with those of its antipodes, Europe and Britain, or of North America. Among the latter from Silurian beds, are *Halysites escharoides*, *Alveolites repens*, *Favosites cristata*, *F. Forbesi*, *F. aspera*, *F. fibrosa*, *F. Gothlandica; Chonetes striatella*, *Leptæna quinquecostata*, *L. compressa*, *Strophomena pecten*, *S. rhomboidalis*, *Pentamerus Knightii*, *P. oblongus*, *Orthis canaliculata*, *Atrypa reticularis*, *A. hemisphærica*, *Spirifer crispus*, *Meristella tumida; Pterinea ampliata*, *Orthoceras ibex*, *Cheirurus insignis*, *Encrinurus punctatus*, *Calymene Blumenbachii*, *Bronteus*

Partschii, *Harpes ungula*, and others; and there are as many from the later Paleozoic. The author hence confirms the conclusion expressed by McCoy, with regard to the general specific identity of the marine fauna of the two hemispheres in the Silurian age, and extends it to all Paleozoic time, including the Carboniferous age, so that we may say that "the entire marine Paleozoic fauna was subjected to the same general influences." The species occur in many cases of larger size than in Europe or America. Prof. de Koninck states that he was mainly indebted for the specimens he has described to the Rev. W. B. Clarke, who has long worked in Australian Geology.

11. *On the Syenitic mountains of Ditro, and the Trachytic, Hargitta, near Büdösch in Eastern Transylvania, with observations on the Auriferous Districts of Vöröspatak and Nagyag*, by Prof. G. vom Rath. 55 pp. 8vo. Bonn, 1876.—The Syenitic mountains of Ditro, described by Prof. vom Rath, extend from Gyergyo Szt. Miklos to Szarhegy and Ditro, having a length of twenty to twenty-one kilometers and a breadth of seven to eight. They consist mainly of "nepheline-syenite" *miascyte*, and "sodalite-syenite" or *ditroyte*. The former, which is the predominating rock, consists of a gray to greenish-gray nephelite (elæolite), white orthoclase and oligoclase, black hornblende with some biotite, zircon, sphene, magnetite, and pyrite, and is either coarse or fine grained. The elæolite is in grains and occasionally in masses two-thirds of an inch through. The miascyte graduates into the ditroyte, or a rock containing blue sodalite and sometimes cancrinite and pyrochlore in addition to the ingredients of the miascyte. The orthoclase of the ditroyte gave Prof. vom Rath the oxygen ratio 1·018 : 3 : 11·438; and the blue sodalite was found by him to consist of

$$\ddot{\mathrm{Si}}\ 38{\cdot}66,\ \dddot{\bar{\mathrm{A}}\mathrm{l}}\ 32{\cdot}61,\ \dot{\mathrm{Ca}}\ 0{\cdot}95,\ \dot{\mathrm{K}}\ 1{\cdot}04,\ \dot{\mathrm{Na}}\ 13{\cdot}28,\ \mathrm{Na}\ 3{\cdot}93,\ \dot{\bar{\mathrm{H}}}\ 2{\cdot}36,\ \mathrm{Cl}\ 6{\cdot}08.$$

In these mountains there is also a reddish quartzless syenyte-like rock, consisting of a reddish orthoclase, black biotite and hornblende with some yellow sphene.

Prof. vom Rath describes in this paper also the trachytic rocks of the vicinity and their relations, giving analyses of the andesite or plagioclase feldspar; and then discusses the auriferous region and rocks of Vöröspatak and the auriferous tellurium regions of Nagyag (pronounced Nadj-ák). In the Vöröspatak region, as cited from Grimm, the gold-bearing rocks are: (1) the Carpathian sandstone referred to the Eocene containing beds of argillyte, and having vertical ore-bearing veins; (2) a feldstone-porphyry, which is stated to be an eruptive rock, containing quartz in numerous and large dihexahedral crystals; and (3) a "porphyritic sandstone newer than the Carpathian, which is accompanied by a crystalline slate, and sometimes becomes a breccia, and is intersected by numerous small veins of quartz and pyrite.

12. "*Greenstones*" *of Western Cornwall;* J. Arthur Phillips, Esq. (Q. J. Geol. Soc., May, 1876.)—This paper has special interest on account of the various opinions with regard to the

relations of diorytes and other "greenstones." The rocks which it describes are greenish slates, greenish crystalline rocks without a trace of lamination, into which the slates pass by gradual or abrupt transitions, and also killas or clay-slate. The kinds of greenstone least metamorphic consist, as seen in thin sections under the microscope, of a plagioclase feldspar, augite or diallage, magnetic titanic iron, with occasional specks of pyrite, and also a little apatite, and with rarely flakes of brown mica, some hornblende, and a chlorite. The more altered kinds have a semi-transparent base, through which hornblende and the chlorite are thickly disseminated; and in it there are green pseudomorphs after augite, and faint outlines of feldspar crystals. In some places there are large crystals of the feldspar, yet with the augite changed to hornblende and chlorite. The material of the intersecting veins is the same, except that it contains a little more green hornblende. In other places the augite is but slightly altered, while the feldspar crystals appear merged in a colorless slightly opaque base, which shows faintly the outlines of the feld spar crystals.

Four different varieties of the greenstones afforded on analysis:

	I.	II.	III.	IV.
Silica	46·32	47·22	43·48	47·26
Alumina	18·18	19·85	18·60	21·64
Ferric oxide	0·82	1·01	3·68	3·97
Ferrous oxide	10·92	9·87	11·38	8·92
Manganous oxide	*trace*	*trace*	*trace*	*trace*
Magnesia	7·46	6·30	6·01	4·02
Lime	9·32	10·18	12·31	6·01
Potash	2·07	1·12	1·12	1·91
Soda	2·95	2·13	1·69	3·77
Phosphoric acid	0·52	0·95	*trace*	0·33
Water, hygrometric	0·24	0·21	0·22	0·29
combined	0·76	0·80	1·17	1·92
Pyrite	0·32	0·17	*trace*	*trace*
	99·88	99·81	99·66	100·04
Specific gravity	3·02	2·97	3·01	2·98

No. 1 is greenish and crystalline, and consists, as shown microscopically, mainly of augite and feldspar, the former predominating, with some chlorite, brown and green hornblende, and magnetite; and came from north of St. Peter's Vicarage in Tolcarn. No. 2, from Tolcarn Quarry, resembles No. 1, but is of lighter color, and consists of feldspar with altered augite, chlorite, magnetite partly replaced by a greenish-gray mineral, and apatite. No. 3, from Tolcarn Quarry, is very fine-grained crystalline, sage-green in color, and consists chiefly of hornblende and altered feldspar and chlorite, the augite being replaced by hornblende and chlorite. No. 4, from Chapel Rock ("which rests on slate"), is crystalline and greenish-gray, somewhat felsytic in appearance and consists of a feldspar base, with crystals of feldspar, hornblende in angular patches replacing augite, chlorite, apatite, magnetite.

With these rocks occur fine-grain crystalline slaty kinds, which graduate into killas or clay-slate. These slaty crystalline rocks are bluish-green to greenish-gray; and the slaty structure is sometimes wanting. They consist largely of hornblende in minute acicular crystals, with some chlorite, and not unfrequently a slightly opaque base, and with occasional patches of quartz, and sometimes magnetite. An average slaty kind of a dark color gave on analysis the results in column A below. A rock of grayer color, similarly hornblendic, containing much magnetite, afforded the results in column B.

	A	B	C	D
Silica	37·44	50·51	37·63	48·41
Alumina	16·32	19·69	17·15	17·02
Ferric oxide	7·33	1·28	7·53	2·68
Ferrous oxide	14·75	7·40	16·03	9·41
Manganous oxide	*trace*	*trace*	0·40	*trace*
Magnesia	6·06	8·04	3·52	6·20
Lime	12·83	7·38	13·95	13·15
Potash	1·50	1·00	0·94	0·30
Soda	1·85	3·41	0·95	2·13
Water, hygrometric	0·54	0·20	0·40	0·12
combined	0·77	0·63	1·07	0·65
Phosphoric acid	0·27	*trace*	0·46	*trace*
Pyrite	0·23	----	*trace*	*trace*
	88·89	99·67	100·03	100·07
Specific gravity	3·29	2·89	3·35	3·03

(A hornblende of Botallack, Cornwall, having sp. gr.=3·24, afforded A. G. Phillips—Silica 40·12, alumina 16·75, ferric oxide 4·32, ferrous oxide 12·70, manganous oxide 3·42, magnesia 6·82, lime 12·37, potash *trace*, soda 2·65=100·09.)

A compact greenstone, dark greenish black, and crystalline, from Pendower Cove, in Gurnard's Head District, largely made up of hornblende, with an occasional grain of quartz, afforded the composition in column C, above. Another greenstone, bluish gray and distinctly slaty, from two miles west of Camborne, having sp. gr. =3·03, and consisting largely of flakey hornblende as seen under the microscope, afforded the composition of column D. Another, from North Huel Rose, in Newlyn East, was grayish, and had a chert-like aspect, with a tendency to break into plates. The greenstone rocks in St. Ives District consist of hornblendic slates, interbedded with augitic rocks and occasional bands of clay-slate; those of the Cape Cornwall District are stratified, with usually a distinct slaty cleavage.

Mr. Phillips speaks of the greenstones as in part altered gabbro or doleryte; others as metamorphic hornblendic slates, some of them containing garnet, magnetite or axinite; others as killas or ordinary clay slates, containing usually much more silica than the greenstones; others as metamorphic and highly basic hornblendic rocks, having a tendency to break into thin plates.

From the facts connected with the "greenstones" of the western half of the New Haven region and of New Hampshire, it appears probable that even the rocks of dolerytic composition (the augitic kinds) are ordinary sediments metamorphosed, and constitute either *metadoleryte* or *metadiabase* according to the prevalence of chlorite or not; that part of the hornblendic kinds—those that contain the requisite feldspar—are basic *metadiorytes*, and that the latter pass into hornblendyte (hornblende rock), and also into labradorite-dioryte and anorthite-dioryte, other metamorphic rocks. J. D. D.

13. *Petrographische Studien an den Melaphyrgesteinen Böhmens*, von Dr. E. Boricky. Prag, 1876.—The volume in hand is a continuation of Dr. Boricky's valuable examination of the igneous rocks of Bohemia.

14. *Minerals of New South Wales*, by Prof. A. Liversidge. 63 pp. 8vo. Sydney, N. S. W. 1876.—Prof. Liversidge has given a complete and valuable list of the minerals of New South Wales, with descriptions mostly taken from specimens which he had himself had in hand. The occurrence of gold is described in detail, and an enumeration is given of some of the larger nuggets which have been found. The average chemical composition of the ore obtained is 93½ p. c. gold, and about 6 p. c. silver. E. S. D.

15. *The Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland;* No. 1, August, 1876, and No. 2, November, 1876.—The Mineralogical Society of Great Britain and Ireland was instituted February 3d, 1876, with special reference to the advancement of the Sciences of Mineralogy and Petrology. The officers of the Society are as follows: President, H. C. Sorby, Esq.; Vice Presidents, Rev. Professor Haughton and Professor Heddle; Treasurer, R. P. Greg, Esq.; General Secretary, J. H. Collins, Esq.; Foreign Secretary, C. Le Neve Foster, Esq. The first two numbers of the Society's Journal contain a number of interesting papers; among these are descriptions by Mr. J. H. Collins of the following new minerals:

Henwoodite. Occurs in globular masses of a turquois-blue or bluish-green color upon limonite; the exterior surface of the masses shows indistinct crystalline facets. H.=4–4·5, G.=2·67. Analysis: P_2O_5 48·94, $\cancel{\text{A}}\text{lO}_3$ 18·24, $\cancel{\text{F}}\text{eO}_3$ 2·74, CuO 7·10, CaO 0·54, SiO_2 1·37, ign. 17·10, loss 3·97=100·00. It is somewhat related to lazulite, wavellite, and turquois, but differs in the relative amounts of alumina and phosphoric acid. Found at the West Phœnix Mine in Cornwall.

Enysite. Occurs in stalactitic forms in a cave at St. Agnes, Cornwall. H.=2–24, G.=1·59. Color bluish-green. B.B. infusible; in the closed tube yields much water. Analysis: SO_3 8·12, $\cancel{\text{A}}\text{lO}_3$ 29·85, CuO 16·91, CaO 1·35, SiO_2 3·40, H_2O 39·42, CO_2 1·05, Na_2O, Cl, $\cancel{\text{F}}\text{eO}_3$ tr.=100·10. The mineral is regarded as one of comparatively recent origin. E. S. D.

16. *Prospectus of the "Zeitschrift für Krystallographie und Mineralogie," under the editorial charge of Prof. P. Groth, "unter Mitwirkung zahlreicher Fachgenossen des In- und Auslandes."*—In this prospectus Dr. Groth gives in full the plan and objects of his new Journal of Crystallography and Mineralogy,

the proposed publication of which has already been announced in this Journal (vol. xii, p. 152). The Zeitschrift will fill a place hitherto unoccupied by any scientific publication, being especially devoted to the science of Crystallography in its relation particularly to Mineralogy, and also to the departments of Chemical and Physical Mineralogy. It will thus cover the whole field of mineralogy. Moreover, in addition to original articles, it will contain abstracts of all mineralogical papers wherever they may appear, and in whatever language, and thus become a complete repertorium for the science. To carry out this part of the work, certainly not the least important, the editor has secured the coöperation of leading active mineralogists in England, America, Italy, Denmark, Norway, Russia, Hungary, Bohemia, etc. It is hence evident that the Zeitschrift will be a most invaluable help to all workers in this field of science; and it is much to be hoped that the distinguished and energetic editor will find the hearty support which he deserves, not only in Germany, but in all countries where the science is cultivated. It will be published in octavo numbers of 6 to 7 signatures, commencing with January, 1877. Each volume will include six numbers, and, with the accompanying plates, will cost not more than 30 marks. Authors of original articles will receive free twenty-five extra copies. The publisher is W. Engelmann in Leipzig.

III. BOTANY AND ZOOLOGY.

1. *Ulothrix zonata. Ihre geschlechtliche und ungeschlechtliche Fortpflanzung;* Dr. ARNOLD DODEL.—This paper, which fills the greater portion of the fourth part of the tenth volume of Pringsheim's Jahrbücher, is an important contribution to our knowledge of sexuality in plants in its simplest phase. In spite of the methodical arrangement of the article, it is elaborated with such excessive minuteness, accompanied occasionally by somewhat futile speculation, that it is by no means an easy task to read it. This is to be regretted, as many of the facts brought forward are quite curious. The genus *Ulothrix* belongs to the order *Zoösporeæ* in which the reproduction takes place by means of macrozoöspores and microzoöspores, the former having four cilia and one germinative spot (the name given to the reddish-colored dot found on one side), the latter having only two. The former bodies have for some time been considered non-sexual, while the latter have been supposed to represent sexual organs which by their union form a body with four cilia, and distinguished from the macrozoöspores by having two germinative spots instead of one. This body, which is called the zygospore, corresponds to the organ of the same name in the *Desmideæ* and *Conjugatæ* proper. Dodel confirms the views of Areschoug, Cramer and others, that the macrozoöspores do not conjugate, but, after losing their cilia and coming to rest, grow at once into a new plant. He also agrees, in the main, with Areschoug as to the conjugation of the microzoöspores, and besides has been able to give a more exact account

of what becomes of the zygospores. He finds that they remain for a considerable time unchanged, and finally divide into a number of zoöspores, which soon come to rest and grow into new plants, as in the case of the macrozoöspores. The latter it appears are more common in winter and spring, and were produced abundantly on thawing tufts which had been frozen, while the microzoöspores are more common in summer.

The most curious fact observed by Dodel is that those microzoöspores which, for any reason, do not succeed in conjugating, grow at once into new plants just as in the case of the macrozoöspores. In other words, the sexual process is reduced to the direct union of two bodies so similar that it is impossible to distinguish one as male and the other as female, and furthermore these bodies, if not placed in conditions favorable for conjugating, can at once grow into new plants. It would be difficult to find sexuality of a lower grade than this, where each sexual organ is also capable of reproducing the plant by non-sexual growth. We would recall the case of *Eurotium herbariorum* mentioned by De Bary, where, of the several male organs (pollinodia) only one succeeds in coming in contact with the female organ, yet all, after the fertilization has taken place, continue to grow and take part in the formation of the sac which eventually encloses the spores. With very rare exceptions in the Thallogens, the male organ at once atrophies after fertilization has been accomplished.

W. G. F.

2. *De Copulatione Microzoosporarum Enteromorphæ compressæ*, (L.) Scripsit J. E. Areschoug, ex Botaniska Notiser. 1876. No. 5.—In their Observations sur quelques algues possédant des zoospores dimorphes, Janczewski and Rostafinski called in question the observations of Areschoug in which he maintained that the microzoöspores of *Enteromorpha compressa* conjugated. In the present paper Areschoug gives a detailed account of repeated observations of the conjugation of microzoöspores of *Enteromorpha compressa* made during the past summer, and it would appear that Janczewski and Rostafinski had been too hasty in their criticisms. Areschoug mentions that Wittrock has found zygospores in *Hæmatococcus lacustris* (*Protococcus nivalis*) the existence of which Rostafinski denied. W. G. F.

3. *Professor Sir Wyville Thomson on some of the Echinoderms of the* "*Porcupine*" *and* "*Challenger*" *Expeditions.*—One of the recent numbers of the Transactions of the Royal Society of London contains an account by Professor Thomson of the Echini of the "Porcupine." The most interesting portion is a full description with excellent figures of several species of the new family of Echini with flexible test, intermediate between the Cidaridæ and Diadematidæ, the genera *Thermosoma*, *Calveria* and *Asthenosoma* constituting the family. The structure of the Echinothuriæ, as this family has been called by Sir Wyville, throws a good deal of light on the affinities of the extinct Palæechinidæ.

In addition to the Crinoids noticed by Professor Thomson in one of his former preliminary reports addressed to the Royal Society, he has published a short account of two remarkable genera belonging to the family of Apiocrinidæ, which are described as *Bathycrinus* and *Hyocrinus*, the former from a depth of 2475 fathoms, south of Cape Clear, the latter from a depth of 1850 fathoms, 300 miles east of St. Paul's Rocks. The paper is illustrated by five cuts, and forms the beginning of No. 66 of the Journal of the Linnean Society for December, 1876. *Bathycrinus* is allied to *Rhizocrinus*, while *Hyocrinus* has a superficial resemblance to *Poteriocrinus* and *Cyathocrinus*. In the same number of the Journal of the Linnean Society, Sir Wyville Thomson has given a most interesting account of the direct mode of propagation in a number of Echinoderms, showing that this mode of reproduction is not so exceptional among Echinoderms as was formerly supposed. The direct mode of reproduction was already known in all the orders of Echinoderms (Holothurians, Ophiurans, Starfishes, Echini and Crinoids). It had however been supposed that the plutean development was the normal mode of reproduction among Echinoderms, although the complete homology between the direct and plutean embryology has been pointed out by several writers on the Echinoderms. The sketch referred to shows most conclusively that this view was correct and opens a most interesting field of speculation regarding the causes which may have brought about, often in closely allied genera, one or the other mode of reproduction. It is somewhat curious that the majority of cases of direct reproduction are of species found in the northern regions of the old world, the species observed by Professor Thomson are all from the Southern Sea; Falkland Islands (*Cladodactyla crocea* Lessen, *Goniocidaris canaliculata* A. Ag.); Heard Island (*Prolus ephipper*); Kerguelen Isls. (*Cidaris nutrix* W. T., *Hemiaster*, sp. *Archaster excavatus* W. T., *Hymenaster*, and *Ophiocoma didelphys* W. T. These species are all figured with the young as they are carried about by the parent. A. AG.

4. *Zoology of the Challenger Expedition.*—The editors learn by letter from Mr. ALEXANDER AGASSIZ (dated Edinburgh, Dec. 18) that he has found the material a wonderful collection, and was deeply impressed by the great amount of it, coming as it mainly does from the depths with which we formerly associated the idea of a lifeless desert region. He also gives the following information respecting the publication of the results. "The Admiralty is to publish the results and the collections are to be worked up by sundry specialists: Allman the Hydrozoa; Busk the Polyzoa; Dr. McIntosh the Annelids; Thomson himself the Crinoids and some of the Sponges, the balance of the latter by O. Schmidt; Hæckel the Radiolaria; Moseley of the Challanger the Polyps; Murray who was on the Challenger will work up the deep sea bottoms and surface animals (Foraminifera, etc.); Günther the Fishes. Some of the groups are not yet determined upon, but the same persons who worked up the "Porcupine" species will probably have charge

of the Challenger collection. Young Carpenter will work up the Comatulæ, Lyman will have the Ophiurans, and I shall bring over with me the Echini and perhaps some other group of Echinoderms, so that the United States will have their fair share of the work."

5. *Rate of Growth of Corals.*—A remarkable piece of coral, taken off the submarine cable near Port Darwin, is spoken of by the Cocktown Herald. It is of the ordinary species, about five inches in height, six inches in diameter at the top, and about two inches at the base. It is perfectly formed, and the base bears the distinct impression of the cable, and a few fibers of the coir rope used as a sheath for the telegraphic wire still adhering to it. As the cable has been laid only four years it is evident that this specimen must have grown to its present height in that time, which seems to prove that the growth of coral is much more rapid than has been supposed.—*Melbourne paper.*

7. *Bulletin of the Nuttall Ornithological Club.* Editor, J. A. ALLEN; Associate Editors, S. F. BAIRD and ELLIOTT COUES.—The November number closed the first volume of this excellent journal. It contains papers by E. Ingersoll, Dr. J. G. Cooper, R. Ridgeway, J. C. Merrill, M.D., U.S.A., and T. M. Brewer, besides notices of recent publications and various miscellaneous notices.

The Journal has the best of American Ornithologists among its contributors, and is afforded at the low rate of one dollar a year (postage included). All interested in Birds, or in the progress of science, will find the small sum asked for subscription a good outlay. The prospectus states that, for the sake of sustaining the Journal, an advertising sheet will be inserted, and low rates of advertisement charged. Subscriptions should be forwarded to Mr. H. B. Bailey, Newton, Mass., and communications or advertisements to Mr. J. A. Allen, Museum of Comparative Zoology, Cambridge, Mass.

IV. ASTRONOMY.

1. *Meteor of Dec. 21st,* 1876.—On the evening of Thursday, Dec. 21st, 1876, a meteor of unusual size and brilliancy passed over the States of Kansas, Missouri, Illinois, Indiana, and Ohio. In many respects it is worthy of special record. From newspaper notices that we have been able to collect, from a few private letters, and from some letters kindly sent us by Prof. Henry, from the Smithsonian Institution, we are able to give a general account of the body.

It was first seen, so far as we know, over the State of Kansas, and probably as far west as the center of the State. It passed nearly over and probably south of the cities of Topeka and Leavenworth, being there at an altitude of about 60 miles. It crossed the Mississippi between Hannibal and Keokuk, but nearer to the former place. Over the center of the State of Missouri one or more explosions occurred, and shortly after crossing the Mississippi it broke into several fragments. The breaking up continued while it was crossing the States of Illinois, Indiana and Ohio. A loud explosion is reported as far east as Concord and Erie, Pa. The meteor consisted in fact of a large flock of brilliant balls chasing each other across the sky, the number being variously estimated from a score to a hundred. This flight is of peculiar interest in view of the long continued violent disintegration.

The region around Chicago was overcast, and though the clouds were lighted up in a most remarkable manner no sound seems to have been heard. In like manner no sound is reported from St. Louis. But over all the region of Central Illinois between these two cities a terrific series of explosions were heard. In Keokuk, Ia., it was heard, but not elsewhere in that State so far as appears from these accounts. A rumbling is reported as far south of the track as Bloomington, Ind., 120 miles distant, but whether it was caused by the meteor is doubtful. Yet over the northern part of Indiana the passage of the body was followed by loud explosions.

Whether a portion of the body pursued its way onward over New York State and out of the atmosphere is from the statements before us doubtful. The path was nearly parallel to the earth's surface and might easily be in its latter part upward. But if the sky was then clear over western New York the meteor would in such case certainly have been seen in that region.

The path was about N. 75° E., and was nearly or quite a straight line and not less than 1,000 miles long. The duration of flight was of course variously estimated, from fifteen seconds up to three minutes, and yet no one probably saw the body through more than a fraction of its path.

It entered the air in a course differing only about 30° from the earth's motion and was overtaking the earth. Its real motion made therefore a still smaller angle with that of the earth. But the relative velocity was so slow, probably not over ten or fifteen miles a second, that the earth's attraction had changed its direction greatly. It must have been coming, previous to that change, from a point near to and a little south of the ecliptic in the eastern or southern part of the constellation Capricornus. There appears to be no known meteor-radiant at that time near that part of the heavens.

Should no one else undertake the complete discussion of this meteor, we may treat it more fully in a future number of the Journal. We shall be grateful for any accounts of observers—especially of those who made angular measurements—whether we shall use them ourselves or place them in the hands of others for reduction. H. A. N.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Bressa Prize, of the Turin Academy of Sciences.*—The fund for the Bressa prize—instituted by the bequest of M. César Alexandre Bressa, Doctor of Medicine and Surgery, who died in 1835—became available in 1876. A prospectus issued by the Royal Academy announces that, in carrying out the will of the testator, a prize, amounting to the income of two years, will be given in 1879, and every four years thereafter, to the man of science, *of*

whatever country, who shall, in the judgment of the Academy, have made, during the preceding four years, the most brilliant and useful discovery, or shall have published the most celebrated work, in pure or applied mathematics, or in the physical sciences, such as physics, chemistry, physiology, natural history, or in geology. pathology, history, geography or statistics; and, secondly, the same amount, on the same conditions, in 1881, and every four years thereafter, to an Italian savant. The prize will not be given to any of the National members of the Academy, resident or non-resident. The amount of the prize given in 1879 will be 12,000 francs.

2. *Annual Report of the Board of Regents of the Smithsonian Institution for* 1875.—The work of the Smithsonian Institution covers a wide range of subjects of both economical and scientific importance, and has a powerful influence for good on the welfare and scientific progress of the nation. As one example we cite the fact, stated in this report, that the department of the Institution having charge of fish-culture, which is under the direction of Professor Baird, distributed in the years 1874, 1875, of young shad, 18,689,550; of Penobscot salmon, 2,294,565; of California salmon, 4,581,340; making in all over twenty-five and a half millions which, with the distribution during the winter and spring of 1875-6, of these and other fishes, make a total of forty million fish supplied by the Commission in three years. The Report on the Museum shows great increase. One object of special interest acquired during the year, is the Tuczon meteorite, presented by Dr. B. J. D. Irwin, U. S. A. The very extensive collections displayed by the Smithsonian Institution at the International Exposition at Philadelphia were second in interest to none there exhibited. Very much of the credit connected with it is due to Dr. S. F. Baird, the assistant secretary of the Institution, who gives in this volume a statement of the general scheme of arrangements.

The general appendix to the Report contains the following papers,—Eulogy of Volta, by ARAGO; The probable future of the Human race, by A. DE CANDOLLE; Report on the Transactions of the Society of Physics and Natural History of Geneva, 1873 to July, 1874; The "Past and Future of Geology," by JOSEPH PRESTWICH; Report of the Special Committee for the Consideration of the Memoir of H. G. Wex on the diminution of the water of rivers; The refraction of Sound, by WM. B. TAYLOR; On the organization of local Scientific Societies, by Professor HENRY; On Ethnology: International Code of Symbols for Charts of Pre-historic Archæology, translated by O. T. Mason; Characteristics of Ancient Man in Michigan, by H. GILMAN; The Stone Age in New Jersey, by Dr. C. C. ABBOTT. The Ethnological papers are illustrated by a large number of figures of stone implements, skulls, etc.

3. *The Theory of Sound in its relation to Music;* by Professor PIETRO BLASERNA, of the Royal University of Rome. 188 pp. 12mo, with numerous woodcuts. New York, 1876. (D. Appleton & Co.)—This is a popular work in style by one who is deeply versed in the science of the subject of which it treats, and knows how to present its principles and facts briefly and clearly.

THE

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[THIRD SERIES.]

In Memoriam.—Fielding Bradford Meek.

The readers of this Journal were informed in the January number of the death of Mr. F. B. Meek, the eminent Paleontologist. He died at Washington, D. C., on the 21st of December, 1876, having only a few days before completed his 59th year. He had been in ill health for several years past, and indeed almost all his life, for his malady was inherited *phthisis pulmonalis.* It had been his habit for several years, to spend the winter in Florida, and the summer months in the Alleghany Mountains. He had made preparation to leave Washington for Florida early in December, but was taken with hemorrhage of the lungs on the day before the one set for his departure. From this attack he never rallied, but gradually sank to a peaceful and quiet death. During his last sickness he was constantly attended and cared for by his scientific and other friends, resident in the city; and when the end came, they bore him to his grave with sincere sorrow.

Mr. Meek was born in the city of Madison, Indiana, on December 10th, 1817. His grand-parents were Irish Presbyterians, who removed from the county Armagh to this country about the year 1768, and finally settled in Hamilton county, Ohio. His father, together with his family, removed from there to Madison, where he was a lawyer of considerable eminence. The family, including those born in Madison, consisted of the parents, two sons and two daughters, besides Fielding, all of whom were dead several years before his own decease. The father died when the son who was to become so distinguished was only three years old, leaving the family in moderate circumstances.

His early youth was spent in the city of his birth. His education was greatly interfered with by the delicate condition of his health. Upon reaching manhood, by advice of his friends and against his own inclination, for he was of a studious and retiring disposition, he invested his small patrimony in mercantile business, first in his native place, and afterward in Owensboro, Kentucky. The result was financial failure and loss of all he possessed. After this, while laboring for his support and struggling with ill health and poverty, he continued his studies, general and special, for he began early to devote himself to natural history. His first public work was during the years 1848 and 1849, and was performed as an assistant of Dr. D. D. Owen, upon the United States Geological Survey of Iowa, Wisconsin and Minnesota.

Having closed this work, he returned to his home in Owensboro; but soon after, in the year 1852, went to Albany, New York, as assistant to Professor Hall in the paleontological work of that State. He remained there until 1858, saving three summers. Two of these summers were spent on the Geological survey of Missouri; the other, that of 1853, in exploring the Bad-lands of Nebraska, together with Dr. F. V. Hayden, both being commissioned by Professor Hall for that work. Three years after this exploration, he prepared for publication, in conjunction with Professor Hall, an important memoir on Cretaceous fossils from Nebraska. This was published, with illustrations, in 1856, in the Memoirs of the American Academy of Arts and Sciences, of Boston.

In 1858, Mr. Meek left Albany and took up his residence in Washington, where he resided until his death. During all this time, he made his home, and the place of his scientific labors, except when in the field, at the Smithsonian Institution, and it was within its halls that the greatest part of his scientific life-work was accomplished.

The association which he formed with Dr. Hayden in 1853, was tacitly continued until Mr. Meek's death. When Dr. Hayden commenced his explorations in the Western Territories, and afterward organized the Geological Survey of the Rocky Mountain region, Mr. Meek was entrusted with all the Invertebrate paleontology, much of which appeared under their joint names. The most important of these joint publications was the "Paleontology of the Upper Missouri," published by the Smithsonian Institution in 1865, and admitted by all to have been the most thorough and exhaustive work of the kind that had been produced in the United States. During the continuance of this connection with Dr. Hayden, Mr. Meek accomplished many other very important works. Among the more noteworthy of these are, the invertebrate paleontology of the

Illinois State Geological Survey (published jointly with the Director, Mr. A. H. Worthen); that of the Ohio State Geological Survey; a part of that of the California Survey; that of several of the western exploring expeditions, besides those of Dr. Hayden's surveys of the Territories.

It was the custom of Mr. Meek to publish preliminary descriptions of his new species, and afterward elaborate and illustrate the subjects for final publication. These preliminary papers were published mainly in the Proceedings of the Philadelphia Academy of Natural Science, while his reviews, and memoirs on the higher groups were largely published in this Journal.

Only a few months before his death Mr. Meek finished what he considered to be the most important of work his life, namely: A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country. This work constitutes volume IX of the quarto series, of the U. S. Geological Survey of the Territories, and contains more than 600 pages of text, and 45 plates.

Of the character of Mr. Meek's scientific labors, it is only necessary to speak briefly. Thoroughness, scrupulous exactness, and nice powers of discrimination, are manifested in all his labors; and, with such. merits, his works will shed lustre upon his name as long as paleontology shall be studied. No one in America has done more than he, to systematize and advance the science to which he devoted his life.

His personal character cannot be too highly eulogized, for it was without a blemish. He was a genial, sincere, pure-minded, honorable man. Gentleness and candor were apparent in every expression of his face, and in every word he uttered; but he was self-reliant, and ready at all times to stand up and defend what he believed to be right; and with his keen sense of justice, he was seldom mistaken as to what was right. He was never in vigorous health and often ill; but never complaining, always hopeful, always cheerful, always at the work he loved so well, always helpful of others. His hearing began to fail in early manhood, and the affliction increased until he became entirely deaf, several years before he died. Even when cut off from conversation with his fellow men his cheerfulness did not forsake him; but he seemed to derive great pleasure from written communication with his friends. He was never married, and leaves no near relatives; but all with whom he was ever brought in contact will remember him with pleasure, while to those who were permitted to enjoy scientific intercourse or correspondence with him during his life, his memory will be especially dear.

C. A. W.

ART. XX.—*Notes on the Age of the Rocky Mountains in Colorado;* by A. C. PEALE, M.D.

IN the "Report upon Geographical Explorations and Surveys west of the 100th Meridian, in charge of Lieut. Geo. M. Wheeler, vol. iii, Geology," Prof. John J. Stevenson, on the "Structure and age of the Rocky Mountain System," in Chapter XVII of his report, makes the following statement (p. 501): "The Rocky Mountain system, then, is the result of four especially marked upheavals, the first at the close of the Carboniferous, the second at the close of the Trias, the third at the close of the Cretaceous, and the fourth during the Tertiary. Of these, the first and third were the most general in their effects."

These conclusions he deduces from his investigations during the season of 1873, in the "area embraced between the meridians of 105° and 107° west from Greenwich, and between the north latitude 39° 45′ and the southern boundary of Colorado, giving a length of one hundred and ninety miles, and a breadth of about one hundred and six." (p. 307.)

My duties, as one of the Assistants of Dr. Hayden's Geological Survey of the Territories, have taken me over the same area, and as far west as the meridian of 109° 40′. From my study of this region, and the results of the work of my colleagues on the Survey, I am led to conclusions differing from those reached by Prof. Stevenson in regard to the age of the Rocky Mountains in Colorado. The data obtained are, however, too few to enable us to extend the generalizations to the *entire* Rocky Mountain system.

The first statement of Prof. Stevenson that I shall consider is the following. "The first great epoch of accelerated disturbance in the Rocky Mountain region, resulting in permanent elevation of the surface, was synchronous with that during which the Appalachian chain was completed." (pp. 499, 500.)

He bases this statement upon the following facts (?):

1st. The occurrence of Paleozoic strata high up on the flanks of the mountains and the absence of the Trias in the interior, and the abutting of the Cretaceous against the Paleozoic, (with the exception of the Elk Mountains.) p. 499.

2d. The want of conformability between the Paleozoic rocks and the Mesozoic rocks. (p. 499.)

I will take these up in order:

1st. *The occurrence of Paleozoic strata and the absence of the Trias in the Interior.* I use the name Triassic to denote the Red Beds that have been so called generally in the west. It is so used by Prof. Stevenson. Prof. Stevenson says, (p. 499): "In the interior* no rock of more recent origin than the Carboniferous is involved in the main axes." Again he says, (p. 495): "In the main portion of this second group (including Blue River Range, Park Range, Sangre de Cristo and Spanish Range, and Arkansas or Saguache (*Sawatch*) Range, see pp. 490, 491,) no rocks occur of later date than the Carboniferous, which with the underlying Silurian may be traced along the eastern face to the Blue River."

On the west side of South Park, the sedimentary formations† are present from the Primordial to the top of the Cretaceous, all conformable and dipping to the eastward, extending from the summit of the Park Range eastward into South Park. I grant that on the summit and slopes of the Range, the entire series is not seen, but simply because the range has been subjected to erosion. At some places only Silurian beds are seen and at others both Silurian and Carboniferous. Commencing at the summit of the range and going eastward into the Park, we find, with the exception of faulting in the Carboniferous and Silurian strata, which probably occurred in Post Cretaceous time that the formations succeed each other in regular order. The sequence is uninterrupted. It is true that when we compare the dip of the Carboniferous rocks on the range, with the dip of the Cretaceous out in the park, that it is not precisely the same, but we must remember that the outcrops are three or four miles apart. The inclination in both cases is in the same direction, and if the Cretaceous beds were continued to the summit of the Range as they did originally, we should find them conformable to the Carboniferous; and were we to sink a shaft at the base of the Cretaceous outcrop in the Park, we should doubtless note the conformability of the Cretaceous with the underlying Paleozoic strata. When we cross the upturned edges of the strata we find no uncomformability.‡

Crossing the Park Range to the Arkansas Valley, we find no sedimentary beds on the eastern front of the Sawatch Range. As pointed out by Dr. Hayden § and myself ‖ in 1873, the sedimentaries of the Park Range once extended uninterruptedly to the Sawatch Range, but have been removed by erosion. Prof. Stevenson is himself of the same opinion. He says (p. 492): "It is clear then that the Paleozoic rocks, the same with those found on the Park Range, at one time reached unbroken from South Park to the Arkansas or Saguache (*Sawatch*) Range. How terrible was the erosion which not only cut away these rocks but also tore out and removed the metamorphic rocks to a depth of 6,000 feet along this valley of the Arkansas."

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* He does not explain what he means by the interior, but I take it to mean the interior of his district.

† Wherever I speak of the entire sedimentary series I mean the sedimentary series as known in the West.

‡ See Report of U. S. Geol. Survey for 1873, pp. 38–47, pp. 212–239.

§ Report U. S. Geol. Survey, 1873, p. 39. ‖ Ibid., p. 246.

He restricts the sedimentaries to the Paleozoic. Why could not this erosion have removed not only the Paleozoic but also the Mesozoic strata? When we go to the north end of the Sawatch Range we find the entire series, from Lower Silurian to Upper Cretaceous, present. It is true that the lower strata project beyond the upper, the latter having been removed by erosion. Starting at one of the Archæan peaks at the northern end of the range and going northward, we meet first with a bed of quartzite, probably Primordial. This forms the capping of the spur, and at Eagle River disappears from sight beneath the beds forming the bluffs on the north side of the river. In the upper portion of these beds which are conformable to the quartzite, I obtained, in 1873, Carboniferous and Permian fossils.* Following the outcrops down Eagle River, we find appearing, one after the other, the other members of the series, Trias, Jura and Cretaceous, resting on the Carboniferous in regular order and conformable.† On the west side of the Sawatch Range the entire series is again seen towards the north.‡ The lines of outcrop can be traced from Eagle River to the Elk Mountains. Between the Elk Mountains and the Sawatch Range there is a gap occupied by the Upper Gunnison, or Taylor River, in which the Sedimentaries are absent. Were it not for the Elk Range, in which we have the result of eruptive action, the sedimentary rocks would be seen dipping away from the Sawatch Range to the westward and becoming horizontal in the plateau region.§

The upheaval of this range, with the subsequent erosion, has so modified the beds and removed so much material, that it is difficult at first sight to understand the relations of the sedimentary series to the metamorphics of the Sawatch Range. We must always make allowances for enormous erosion in this region. There are evidences of it on all sides in the Sawatch and Elk Mountains.

In Southwestern Colorado and Northern New Mexico, the Triassic is also present. (See Report of Macomb, Geology, by Newberry: also Cope, pp. 981–1017, Report of Chief of Engineers, Part II, for 1875.) Mr. Holmes and myself have also identified the Red Beds in Western and Southwestern Colorado, and in the forthcoming Reports of the Survey they will be described.

I think I have shown that the Red Beds (Triassic) are present not only in the interior but also west of the mountains, and that where the Paleozoic rocks alone show, the overlying rocks have been removed by erosion.

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* **Report U. S. Geol. Survey, 1873, p. 245.**

† **Report U. S. Geol. Survey, 1874, pp. 79–84.**

‡ **Report U. S. Geol. Survey, 1873, pp. 245, 266. Report for 1874, p. 80.**

§ **Report U. S. Geol. Survey, 1874, p. 54.**

2d. *The want of conformability between the Paleozoic Rocks and the Mesozoic Rocks.* I have already noted the conformability of the Paleozoic and Mesozoic in the Park Range, and on the north and west sides of the Sawatch Range. Prof. Stevenson (pp. 386, 497, 499, 500) notes unconformability between Mesozoic and Paleozoic along the Eastern Range, (*Front or Colorado Range,*) on the interior axes of elevation, and in the southern part of his area, in the San Juan Mountains, and near Tierra Amarilla, New Mexico. Speaking of the Front Range, he says: "Along the Eastern Range no Carboniferous rocks were exposed at any locality visited by me, but they have been seen elsewhere by others. They must be quite unconformable to the Trias, as it overlaps them very greatly." Along the Front Range the Carboniferous shows only where the overlying Triassic has been eroded away, and whatever unconformability there is, is an unconformability of subsidence and not of upheaval. The difference of dip between the Paleozoic strata and overlying Mesozoic is caused by an abrupt fold and the erosion of portions of the strata. Prof. Stevenson does not seem to remember that as we recede from the axis of elevation the dip of the rocks diminishes, and that if the more steeply inclined portion of the Mesozoic rocks be removed, as we recede from the mountains we meet only with the edges of the strata where they are becoming horizontal, and that the older layers below also flatten out in the same manner. I have already shown the conformability in the interior.

In the reports of Dr. Newberry* and Prof. Cope,† I can find no evidences of the unconformability in the southern portion of the San Juan Mountains and about Tierra Amarilla.

Dr. Endlich says‡ that in his district, "although the Cretaceous beds dip off, apparently uniformly, in the same direction (*with Carboniferous*) unconformabilities were noticed in several instances." These he thinks were due to a gradual rising of that portion which was then land. I am inclined to explain it by the subsidence which, as I hope to show farther on, occurred over so large a portion of what is now Colorado.

The next statement of Prof. Stevenson that I shall consider is, that "The second epoch of elevation began toward the close of the Triassic." (p. 500.)

This he bases on the unconformability between the Trias and the Cretaceous, which he observed along the Eastern Range at

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* In Macomb's Report on the Exploring Expedition to the junction of Grand and Green Rivers.

† In Report of Chief of Engineers, Part II, 1875.

‡ Report U. S. Geol. Survey, 1874, p. 215.

Golden, near Colorado Springs, and near Cañon City (pp. 490, 500), and also in Huerfano Park. Near Colorado Springs we have the following section.* Resting on the Archæan rocks are Silurian and Carboniferous rocks dipping eastward about 10°. Going eastward we next meet with Triassic red sandstones, standing on edge, or inclined past the vertical. From the Trias to the Dakota group of the Cretaceous the dip decreases to 40°, and this gradually diminishes eastward until at Monument Creek it is only 4°. At first sight there would appear to be unconformability, especially close to the Mountains, but the beds are conformable, and the varied dips show the presence of an abrupt fold, which is somewhat obscured by the subsequent erosion.† The same thing occurs near Golden, (see section 13 on plate opp. p. 136, Report U. S. Geol. Survey, 1873.) Mr. Marvine says,‡ "Within exceedingly short distances, then, great changes of dip may occur, and from them, with but slight changes of exposure, unconformability might be inferred. Yet all are perfectly conformable; the sudden change really indicating only a very abrupt flexure in the main fold, as indicated by the dotted lines." Near Cañon City, neither Dr. Hayden, Dr. Endlich, Mr. Holmes, nor myself have noted any unconformability. The other cases are probably similar to those of Golden and Colorado Springs.

What I now wish to show is that in Colorado the evidence exists that there was a subsidence commencing in, or prior to the Carboniferous, and continuing through the Triassic, Jurassic, Cretaceous and into the Tertiary. This may have been, and doubtless was interrupted by oscillations, but the general movement was depression until the close of the Cretaceous, when there were probably local elevations. A general gradual elevation of the whole West is not incompatible with local depression in Colorado. There are evidences that the upward movement began in Cretaceous time, but as pointed out by Dr. Hayden and Dr. Newberry the elevation of the Rocky Mountains took place between the close of the Cretaceous and that of the Miocene Tertiary.

From a study of the Carboniferous rocks in Colorado, we learn that during the earlier part of the Carboniferous age deep seas prevailed with large continental areas or islands. As the time progressed the seas became shallower and encroached more and more upon the land, which was composed mainly of Archæan rocks.

The Coal-measure rocks at the northern end of the Sawatch Range denote in their structure, the proximity of land during their deposition. They also show that they were derived from the degradation of Archæan rocks.* West of the Rio Dolores, in 1875 and 1876, I noted Upper Carboniferous rocks resting on the Archæan, and in the lowest bed, which was a coarse conglomerate, I noted large angular fragments of granitic rock exactly like that upon which the bed rested. Ascending, I noticed the beds becoming finer, showing that the shore line had advanced to the eastward. Farther east the red beds (Trias) rest on the Archæan for at least 20 miles (the length of the Unaweep Cañon) and probably more, with no older sedimentaries between them.

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* Report of U. S. Geol. Survey, 1873, pp. 201–205.

† See sections opp. p. 40, Report of U. S. Geol. Survey, 1874.

‡ Report of U. S. Geol. Survey, 1873, p. 136.

In New Mexico, Dr. Newberry found the Carboniferous rocks resting on the granite, with evidences of terrestrial surfaces near by when they were formed.†

It is evident therefore that there was Archæan land above the level of the Carboniferous sea, and that it was subsiding as the age progressed.

This subsidence continued through Mesozoic time. Along the eastern front of the Colorado or Front Range, with one or two exceptions where they have been removed by erosion, the Red Beds (Trias) rest upon the granite, (see Reports of 1873.) At the base of the series, Mr. Marvine found conglomerates of which he says, "It is in these lower parts, indeed, that the beds are so directly made up of the material of older rocks near by that a very little metamorphism has in some instances made it difficult to distinguish small masses of sandstone from the underlying granites."‡ In my own district, south of Mr. Marvine's, I found the lower bed of the Trias, a light colored conglomerate, containing pieces of unchanged granite. Above this conglomerate, the sandstones became fine-grained and uniformly red in color,§ showing that the shore line had progressed westward. In South Park the Red Beds nowhere rest on the granite; for, on the east side, the Dakota group rests on it, while on the west side the Paleozoic rocks are interposed as I have already stated. Continuing the section westward to the Elk Mountains we again find Paleozoic strata beneath the Trias, but south of the Elk Mountains both the Trias and the underlying Paleozoic are absent, and the Cretaceous is superimposed on the granite. Following down the Gunnison we find the underlying rocks coming in gradually until the Red Beds show resting on the granite. West of the Elk Mountains, between the Gunnison River and the Rio Dolores. the Trias rests on the granite, gradually thickening as we go westward. No lower strata are seen until

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*** Report U. S. Geol. Survey, 1873, pp. 243–245, and Report of 1874, pp. 114–120.**

† Report Expl. Exped. to junction of Grand and Green Rivers, pp. 17 and 42.

‡ Report U. S. Geol. Survey, 1873, p. 96. **§ Ibid., pp. 194, 195.**

we get within about five miles of the Dolores, when Upper Carboniferous strata appear, with every evidence that a shore line once existed there. The outcrop of Red Beds resting on the granite is exposed to view continuously for more than 20 miles. The fact that the Red Beds thin out and disappear as we go east, and that the Jurassic does the same until the Cretaceous alone rests on the granite, points to the fact that the sea was gradually encroaching on the land, and there must have been a subsidence here extending into Cretaceous time. South of the Gunnison River are small areas of Archæan rock where trachytic flows rest upon them with no sedimentaries interposed, and in others the Archæan rocks project through the trachyte forming isolated granite hills.

In South Park, on the west side as I have already said, the entire series of sedimentaries from Primordial to the top of the Cretaceous is present, while on the east side the Dakota group rests on the granite. Prof. Stevenson acknowledges that there was subsidence during the formation of the Triassic rocks, as far as the Front Range is concerned. He says, (p. 500), "In this region there was a subsidence during the deposition of the Trias which affected the interior little, if at all, for over the greater portion of that area the Trias is altogether wanting." Again he says, (p. 490), "In South Park the Cretaceous rocks rest directly upon metamorphic rocks, and are themselves more or less altered. At no locality were they seen resting upon any sedimentary rocks older than themselves." I have shown that Triassic rocks show at more than one locality in the interior. On the east side of South Park the Dakota Group rests on the granite, with shales above it containing well defined Cretaceous fossils. On the west side the Dakota Group rests on Jurassic shales, beneath which are the massive Red Beds of the Trias.*

Under the head of Carboniferous, Prof. Stevenson refers to exposures of coarse sandstones and siliceous limestones on the west side of the Park extending 8 miles east of the mountains, (p. 373), and under the head of Cretaceous he says, "In South Park the Cretaceous rocks occupy a synclinal trough, lying east from Fair-Play, and extending from the mountains at the north to very near the southern boundary of the park, (p. 389)." He does not appear to have seen the Jura and Trias between the Cretaceous and Carboniferous in South Park (see Reports U. S. Geol. Survey for 1873), or if he did, failed to recognize it, as I can find no reference to them under his heading Triassic and Jurassic, (pp. 378–382.)

In Middle Park, Mr. Marvine found the No. 1, Cretaceous

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* **Report U. S. Geol. Survey, 1869, p. 79, and Report for 1873, pp. 38–47 pp. 212–239.**

(Dakota Group) resting on the granite on both sides of the Park.* Following these outcrops farther north, in 1874, he found both Jurassic and Triassic beneath the Cretaceous on the granite, and on the west of the Park Range the whole series of sedimentaries is present.† Speaking of Middle Park he says,‡ "As was first distinctly pointed out by Newberry (Amer. Assoc. Meeting, Newport, R. I., 1860, also later Proc. Amer. Assoc., Aug., 1873, p. 185, etc.), east of the range, so here in the Middle Park, the general aspect of the formation as a whole is that of a 'circle of deposition,' an encroaching shore line deposit of sandstones attending slow submergence, followed by a deeper water sediment forming slates and shales, but not reaching sufficient depth or attaining the proper conditions to develop extended limestone deposits; in turn followed by a shallowing sea with more arenaceous accumulations." The area of Middle Park, therefore, must have been above the level of the Triassic sea, whose shore line was north of the park but gradually encroaching on it, so that in Cretaceous time the subsidence was sufficient to allow the deposition of the Cretaceous rocks.

Prof. Stevenson says, (p. 500), "It is probable that following this upheaval [*at the close of the Trias*] an extensive subsidence took place over our whole area to admit of the deposition of the Cretaceous, which occurs not only on the plains but along all the old interior synclinal troughs and in the southwest region. The close of the Cretaceous was marked by violent disturbance throughout the greater portion of our area. Along the edge of the plains the dip of the rocks is from 10° to 20°, though in some localities the action was excessive, turning the strata on edge or pushing them over at Golden and the Garden of the Gods. In South Park a well defined synclinal was produced."

By referring to the sections in the Reports of the U. S. Geol. Survey for 1873 and 1874, it will be seen that the Lower Tertiary‖ is conformable to the underlying Cretaceous. In South Park toward the northern end, in 1873, I found Lower Tertiary fossils in beds resting on the granite toward the east.§ What the relations were to the Cretaceous at the west I was unable to determine on account of volcanic action. At some points along the eastern front of the Colorado Range, the Lower Tertiary overlaps the Cretaceous and rests on the granite.¶ In Middle

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* See sections opp. p. 192, Report U. S. Geol. Survey, 1873.

† Unpublished geol. map of Colorado, U. S. Geol. Survey.

‡ Report U. S. Geol. Survey, p. 156.

‖ It is best to state here that by Lower Tertiary I mean the debatable Lignitic Group which Prof. Stevenson regards as Cretaceous.

§ Report U. S. Geol. Survey, 1873, p. 219, and section Fig. 1, Plate VI opp. p. 212.

¶ See line of coal outcrop map of base of mountains opp. p. 40, Report U. S. Geol. Survey, 1874.

Park Mr. Marvine found the Lower Tertiary and the underlying Cretaceous conformable except at one point.[*] In southwestern Colorado the Cretaceous and Tertiary appear to be conformable, while in the northwestern part of the state the strata were apparently conformable from the base of the Cretaceous to the middle of the Miocene. This may be because of the distance from the axis of elevation, the elevation not being sufficient to lift the area above the sea-level at the end of the Lower Tertiary. I have no evidence in any of my districts of any *violent* action at the close of the Cretaceous. The apparent unconformabilities at Golden and near Colorado Springs I have already explained. There are, however, evidences in some portions of Colorado, of disturbance toward the close of the Cretaceous; but it is not until the end of the Lignitic Period that we find evidences of a geological break.[†] There was probably, as indicated by Hayden and Newberry, an elevation commencing in early Tertiary time, for the marine deposits of the Tertiary change gradually to fresh-water deposits as we ascend, but there was no *marked* action until the close of the Lignitic. There must have been a subsequent depression, for east of South Park near Florissant, we find Miocene[‡] strata resting on granite, with no older beds beneath,[§] and on the Colorado divide, the Miocene rests on the granite of the Front Range and on the upturned edges of older strata. The lowest beds here, also, were evidently made from the material derived from the adjacent mountains. In Middle Park, Marvine found Tertiary beds resting on the granites and on Cretaceous shales, occupying all the lower basins. "Near the borders of these areas these beds often plainly show that their material was derived from the adjacent rock, often being of coarse granitic or schistose *débris*, or of the lignitic sandstones worked over."[||]

From what I have written, I think it is evident that in Colorado, at the close of the Carboniferous, instead of an elevation there was subsidence commencing at some period prior to the close of the Carboniferous, and continuing through the Triassic, Jurassic, and Cretaceous into Tertiary time.

At the close of the Trias we have no evidence of a second epoch of elevation. The close of the Cretaceous was not marked by *violent* disturbance.

I agree with Prof. Stevenson that during the early Tertiary time there was great volcanic activity in Colorado.

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[*] Report U. S. Geol. Survey, 1873, p. 156.

[†] Report U. S. Geol. Survey, 1873, p. 157.

[‡] By Miocene I mean beds of the age of the Green River formation lying below the Bridger Group.

[§] Report U. S. Geol. Survey, 1873, p. 210.

[||] Report U. S. Geol. Survey, p. 157.

The following conclusions are, I think, fairly deduced from the facts as noted in Colorado:

1st. In very early time in Colorado there was Archæan land rising above the Paleozoic sea. As the Carboniferous age progressed this land diminished by encroachment of the sea, due to subsidence of the land. This subsidence continued through Triassic, Jurassic, and Cretaceous time into the early Tertiary.

2d. At the close of the Lignitic there was a physical break followed by a subsidence (at least locally) and subsequently by elevation, after the deposition of the Miocene strata.

3d. The elevation of the Rocky Mountains as we now see them in Colorado, is the result of an elevation commencing in early Tertiary time, and continuing through the period, accelerated perhaps at the close of the Lignitic, and after the deposition of at least Lower Miocene strata.*

The elevation of the mountains was probably gradual as a general movement.

It is an interesting fact that Colorado has a higher mean elevation than any other State or Territory of the United States,† and that we find there the highest mass of mountains, and that the evidence points to the fact that in Paleozoic time also we had here one of the highest areas, thus confirming what Dr. Newberry has already intimated,‡ that the outlines of the western part of the North American Continent were outlined from earliest Paleozoic time.

ART. XXI.—*On some Points in connection with Vegetation;* by Dr. J. H. GILBERT.

[Concluded from page 111.]

Is the nitrogen combined under the influence of the soil with or without the aid of manures, the source of the assimilated nitrogen?—But if the plant itself cannot either assimilate free nitrogen, or effect its combination so as to bring it into a state for its use, may not such combination take place under the influence of the soil?

More than thirty years ago, Mulder argued that in the last stages of decomposition of organic matter in the soil, hydrogen was evolved, and that this nascent hydrogen combined with the free nitrogen of the air, and so formed ammonia.

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* This elevation is probably going on at present also.

† List of Elevations, by H. Gannett, U. S. Geol. Survey, Miscel. pub. No. 1, 3d edition, p. 47.

‡ See Ives Exploring Expedition, Geol. Rep., p. 47, also p. 57 of Macomb's Exploring Expedition to the junction of Grand and Green Rivers.

A few years ago Dehérain substantially revived this view. He maintained that at a certain depth the air of the soil is poor in, or destitute of, oxygen; that hydrogen is evolved from the decomposing organic matter; that it unites with free nitrogen to form ammonia; and, that so, combined nitrogen increases in the soil in spite of the growth and removal of crops. This view he supports by some laboratory experiments.

It is obvious that if the reality of this action in soils were unquestionably established, it would greatly aid the solution of the question we are discussing. There, are, indeed, results of others on record which would seem to lend it probability.

Thus, Bretschneider found, on exposure of a mixture of humic acid and quartz sand to the air for a whole year, under conditions in which it was protected from rain and insects, that there was a gain of combined nitrogen which would represent an increase of more than 40 lbs. per acre.

Again, Boussingault exposed a moist garden soil for three months, and found a small gain of nitrogen. His explanation, was, however, different. He supposed it possible that ozone might be evolved in the oxidation of organic matter in the soil, and unite with free nitrogen, and so nitric acid be produced, and the soil gain in combined nitrogen. In other experiments Boussingault put mixtures of vegetable mould and pure sand in small quantities in large glass vessels which he perfectly closed and preserved in a dark cellar for a whole year. At the end of that period oxidation of organic matter had taken place, nitric acid was found, but there was upon the whole a small loss of combined nitrogen. Lastly in regard to Boussingault's results bearing upon this point, it has already been shown that in all of his experiments with plants in which his soils consisted of ignited pumice, ignited brick, or the like, without organic matter, he found no gain of combined nitrogen in soil and plant. In 1858 and 1859, however, he made a number of experiments on growth, in which part of the soil consisted of rich garden mould; and in two cases with lupins growing in confined air, and in one with haricot growing in free air, his results showed a notable gain of combined nitrogen: and although the quantity of garden mould employed was not the same in the three cases, the gain of nitrogen was approximately in proportion to the amount of soil used. The gain was, indeed, in the soil rather than in the plant. In the other experiments, however, either much less, or no gain was indicated.

Much more recently, Boussingault has published the results of experiments which showed that when a garden soil was confined for about eleven years in closed glass vessels in an atmosphere containing oxygen, the free nitrogen did not serve for the formation of nitric acid within it; but, on the contrary, the soil lost a portion of its combined nitrogen.

Since the delivery of this lecture, M. Berthelot (Compt. Rend., t. lxxxii, p. 1357) has stated that in experiments in which he exposed moistened cellulose to an electric current in an atmosphere of nitrogen, he found nitrogen taken up, and a fixed nitrogenous body formed. Referring to the last mentioned experiments of M. Boussingault, and his conclusions from them, M. Berthelot objects that the soils being in closed glass vessels, the intervention of atmospheric electricity was excluded, and the conditions of the experiments were, so far, unlike those of a natural soil.

Being very desirous to know the present opinion of M. Boussingault on the various points involved in this important question of the sources of the nitrogen of vegetation, I wrote to him shortly after undertaking to give this address, and asked whether he would be kind enough to favor me with a statement of his views on certain points. Unfortunately his reply did not reach me until after the delivery of the lecture; but, with his permission, I am now enabled to contribute a very valuable addition to the discussion in the form of a translation of the more essential parts of M. Boussingault's letter. He says:—

"(1.) In confined stagnant air, or in air moving through a closed apparatus, after previous purification, but still containing carbonic acid, plants growing in a soil destitute of nitrogenous manure, but containing the mineral substances indispensable for the vegetable organism, do not assimilate the nitrogen which is in a gaseous state in the atmosphere."

"(2.) In the open air, in a soil destitute of nitrogenous manure, but containing the mineral substances necessary for the vegetable organism, plants acquire very minute quantities of nitrogen, arising, no doubt from minute proportions of fertilizing nitrogenous ingredients carried by the air, ammoniacal vapors, and dust, always containing alkaline or earthy nitrates."

"(3.) In confined stagnant air, or in air renewed in a closed apparatus, a plant growing in a soil containing a nitrogenous manure, and mineral substances necessary for the vegetable organism, or in fertile vegetable earth, does not assimilate free nitrogen."

"(4.) In field culture, where dung is applied in ordinary quantities, analysis shows that there is more nitrogen in the crops than was contained in the manure applied."

"This excess of nitrogen comes from the atmosphere, and from the soil."

"(A.) From the atmosphere, because it furnishes ammonia in the form of carbonate, nitrates or nitrites, and various kinds of dust. Theodore de Saussure was the first to demonstrate the presence of ammonia in the air, and consequently in meteoric waters. Liebig exaggerated the influence of this ammonia on vegetation, since he went so far as to deny the utility of the nitrogen which forms a part of farm-yard manure. This influence is, nevertheless, real, and comprised within limits, which have quite recently been indicated in the remarkable investigations of M. Schlösing."

"(B.) From the soil, which, besides furnishing the crops with mineral alkaline substances, provides them with nitrogen, by ammonia, and by nitrates, which are formed in the soil at the expense of the nitrogenous matters contained in diluvium, which is the basis of vegetable earth; compounds in which nitrogen exists in stable combination, only becoming fertilizing by the effect of time. If we take into account their immensity, the deposits of the last geological period must be considered as an inexhaustible reserve of fertilizing agents. Forests, prairies, and some vineyards, have really no other manures than what are furnished by the atmosphere, and by the soil. Since the basis of all cultivated land contains materials capable of giving rise to nitrogenous combinations, and to mineral substances, assimilable by plants, it is not necessary to suppose that in a system of cultivation the excess of nitrogen found in the crops is derived from the free nitrogen of the atmosphere. As for the absorption of the gaseous nitrogen of the air by vegetable earth, I am not acquainted with a single irreproachable observation that establishes it; not only does the earth not absorb gaseous nitrogen, but it gives it off, as you have observed in conjunction with Mr. Lawes, as Reiset has shown in the case of dung, as M. Schlösing and I have proved in our researches on nitrification."

"If there is one fact perfectly demonstrated in physiology, it is this of the non-assimilation of free nitrogen by plants; and I may add by plants of an inferior order, such as mycoderms, and mushrooms."

Numerous experiments of Schlösing indicate a similar result to that last quoted of Boussingault. He selected a soil rich in humus, containing about 16 per cent of moisture, and 0·263 per cent of combined nitrogen. Known quantities of it were placed in large wide glass tubes, and during a period of about four months, he aspirated over them air containing respectively from 1·5 to 21 per cent of oxygen. He determined the carbonic acid in the air passing off, and the nitric acid in the soil before and after the experiment. He found that both the combustion of the organic matter, and the formation of nitric acid, were very considerable, even with the lowest proportion of oxygen in the air; but that the formation of the nitric acid in particular was very much the greater, the larger the proportion of oxygen in the air.

In a second set of experiments, he used the soil in a moister condition; and instead of the experiment in which the air contained only 1·5 of oxygen, he employed pure nitrogen; and the experiments extended over a period of about six months. In the case in which the aspirated air contained no oxygen, the whole of the nitric acid previously existing in the soil disappeared; but in the other cases there was a considerable formation of nitric acid.

In a third set of experiments, Schlösing determined the nitric acid in the soils, and added known quantities of potassium nitrate in a dilute solution. The mixture was enclosed in a flask of several times the capacity of the volume of soil. At the conclusion of the experiment only traces, if any, of gas containing hydrogen and carbon were present in the air of the vessel. The amount of ammonia in the soil increased considerably, but in only small proportion to that which the nitric acid would yield. At the end of the first experiment more potassium nitrate was added, and an atmosphere of known volume and composition supplied. At the conclusion of this experiment the soil contained no nitric acid; the amount of ammonia was increased, but again in only small proportion to the amount which the nitrate would yield. There was indeed a loss of total nitrogen in the soil.

Schlösing concludes that the combustion of organic matter in the soil is accompanied by a loss of nitrogen: that the combustion may be at the cost of the air as in the experiment of Boussingault, or at the cost of nitrates, of ferric oxide, or of the oxygen of organic matter, as in his own experiments.

It will be seen that on this important point of whether or not the soil may acquire combined nitrogen either in the form of ammonia by the combination of free nitrogen with nascent hydrogen evolved in the decomposition of organic matter in defect of oxygen, or in the form of nitric acid by the oxydation of free nitrogen, the evidence is, to say the least, conflicting. The more recent results of Boussingault, and those of Schlösing, would, however, indicate a greater probability of a loss of combined nitrogen, and evolution of free nitrogen.

Judging of the probabilities by reference to some of the results of our own investigations, we think that they are rather against than in favor of the supposition that there is any material gain of the kind assumed by Mulder and Dehérain. It may be well, however, briefly to call attention to some few facts which seem to bear upon the point, whether in favor, or otherwise, of the view in question.

The action assumed by Mulder and Dehérain, if it have place at all in soils in their natural condition, would be supposed, and is assumed, by Dehérain, to occur in layers sufficiently deep to be poor in oxygen. In the lower layers of the soil there is, however, a deficiency of carbonaceous organic matter also. Again, if such formation of ammonia do take place, it is probable that some at any rate of it must be oxidized into nitric acid; a condition which, on the other hand, implies an atmosphere not poor in oxygen. Thus, numerous results of analysis of the drainage water from many of the experimental plots at Rothamsted, to which further reference will be made presently, show that nearly the whole of the combined nitrogen in the drainage collected at a depth of about thirty inches, exists as nitrates and nitrites; which, obviously, would hardly be the case if the solution passed through a considerable layer of soil, the interstices of which contained an atmosphere poor in, or destitute of, oxygen.

Again, assuming such formation of ammonia to take place in the upper layers of the soil, where there is the most organic matter, and much oxidation of it, the supposition would be that the conditions would favor oxidation rather than the formation of ammonia from free nitrogen; and the fact of the formation of a good deal of nitric acid by the oxidation of nitrogenous organic matter, or ammonia, in the surface soil, is sufficiently established.

Further, if it were to the action assumed by Mulder and Dehérain taking place in the upper layers of the soil that we owe the supplies of combined nitrogen available to leguminous and other plants which assimilate so much more of it over a given area than the Gramineæ, the question may be asked—why cannot the Gramineæ avail themselves of this superficial supply? On this point it may be mentioned that, on some parts of the experimental wheat and barley fields at Rothamsted, farm-yard manure has been applied year after year, for a quarter of a century or more, in quantity containing perhaps six or seven times as much nitrogen as is removed in the increase of crop, and that thus the percentage of nitrogen in the surface soil has been more than doubled. Yet, as large a produce of barley, and a larger produce of wheat, is annually obtained by the use of very much smaller quantities of nitrogen, as ammonia-salts or nitrate. It would thus appear that the nitrogen of the farm-yard manure was only available to the cereals after its transformation into ammonia or nitric acid. Unfortunately, we are not at present able to adduce direct experimental evidence as to the condition in which the large amount of inefficient nitrogen exists in the soil, or as to whether a leguminous crop would or would not grow luxuriantly in it, but there is little doubt that it would do so. On the other hand, a good crop of clover would appear to be attainable in soil comparatively poor in nitrogen in its upper layers, and comparatively poor in organic matter also; for, in the experiments already referred to in which barley was grown after barley and after clover, the large amount of clover obtained, and nitrogen assimilated in it, was after six corn crops grown by artificial manure alone; conditions under which the amount, both of available nitrogen, and of organic matter, in the upper layers of the soil, would be supposed to be comparatively small.

The answer of Dehérain would probably be, that under the circumstances supposed, the nitrogen would be in a condition of combination not favorable for assimilation by the Gramineæ; that, in fact, the ammonia formed would combine with organic acids in the soil, yielding compounds specially favorable as food for the Leguminosæ. An objection to this view is, that if the accumulation in the soil by time, of nitrogen in a condition specially favorable for the Leguminosæ were such as is here assumed, we should expect the amount of nitrogen in the soil, determinable by the soda-lime process, to be higher before than after the growth of a leguminous crop; whereas, on the contrary, after the growth of a leguminous crop, the amount of nitrogen so determinable in the upper layers of the soil is very appreciably increased.

The evidence in favor of the supposition that the special source of nitrogen to the Leguminosæ is ammonia, or other compounds than nitric acid, in the upper layers of the soil, is then, to say the least, inconclusive. It remains to consider whether it may not be nitric acid, either in the soil or in the subsoil?

As already said, there is abundant evidence of the formation and existence of a considerable amount of nitric acid in surface soils; even in such as contain a relatively high amount of carbonaceous and nitrogenous organic matter. For example, a soil at Rothamsted which has been under garden cultivation, and as such probably manured almost every year for centuries, has successfully grown clover every year for more than twenty years. This soil was shown by the late Dr. Pugh, and has been again recently by Mr. Warington, to contain a considerable amount of nitric acid. But such a soil would, there is no doubt, grow large crops of Gramineæ also; which direct experiments show to attain great luxuriance under the influence of artificially applied nitrates. But such a rich garden soil contains an abundance of every thing—mineral constituents, carbonaceous organic matter, and combined nitrogen in various forms, and thus the exact conditions which it supplies favorable to the Leguminosæ cannot at once be discriminated.

The fact of the comparatively little, or at least uncertain action of directly applied nitrates on the growth of the Leguminosæ, would seem to be inconsistent with the supposition that it is the nitric acid in such a surface soil that has given it its special adaptation for the growth of clover for so many years—unless, indeed, it be the case, that it is much more available to such crops when in combination with some bases than with others.

The next point to consider is, whether there are any facts in favor of the supposition that clover, and leguminous crops generally, acquire any material proportion of their nitrogen in lower layers, and in a more extended range of the soil, than the Gramineæ. As an element in the discussion of this question, it will be well in the first place to call attention to the effects of direct nitrogenous manures, such as ammonia-salt, or nitrates, on the growth of some of our crops.

In Table VIII is shown the estimated amounts of carbon, yielded per acre per annum, in wheat over twenty years, in barley over twenty years, in sugar-beet over three years, and in beans over eight years; each with a complex mineral manure alone, and each with the same mineral manure and given quantities of nitrogen in addition, supplied in some cases in the form of ammonia-salts, and in others as nitrate. The gain of carbon by the use of the nitrogenous manure is also given.

TABLE VIII.—*Estimated yield and gain of Carbon per acre, per annum, in experimental Crops at Rothamsted.*

Manuring, Quantities per acre, per annum.	Average Carbon per acre, per annum.	
	Actual	Gain.
Wheat 20 *years*, 1852–1871.		
	lbs.	lbs.
Complex Mineral Manure	988	
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	1590	602
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	2222	1234
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	2500	1512
Barley 20 *years*, 1852–1871.		
Complex Mineral Manure	1138	
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	2088	1150
Sugar-Beet 3 *years*, 1871–1873.		
Complex Mineral Manure	1136	
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	2634	1498
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	3081	1945
Beans 8 *years*, 1862 *and* 1864–1870.		
Complex Mineral Manure	726	
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	992	266

It is quite evident that in the case of the gramineous crops, wheat and barley, which contain a comparatively low percentage of nitrogen, and assimilate a comparatively small amount of it over a given area, and also in that of the sugar-beet, there was a greatly increased amount of carbon assimilated by the addition of nitrogenous manure alone. In the case of the wheat, there is much more effect from a given amount of nitrogen supplied as nitrate, which is always applied in the spring, than from an equal quantity as ammonia-salts, which are applied in the autumn, and are subject to winter drainage. There is also more effect from ammonia-salts applied to barley than to wheat; the application being made for the former in the spring and for the latter in the autumn. There is again more effect from the nitrate than from the ammonia-salts when applied to sugar-beet, the application being made in both cases at the same date, in the spring.

On the other hand, the effect of the nitrogenous manure upon the highly nitrogenous bean crop is seen to be, comparatively, very insignificant.

In reference to this point, it should be observed that there has been this greatly increased assimilation of carbon in the wheat and in the barley for more than twenty years, without the addition of any carbon to the soil. It is indeed certain that, in the existing condition of our soils, the increased growth of our staple and starch-yielding grains is greatly dependent on a supply of nitrogen to the soil. It is equally certain that the increased production of sugar in the gramineous sugar-cane, in the tropics, is likewise greatly dependent on the supply of nitrogen to the soil.

In reference to the great increase in the assimilation of carbon in the sugar-beet by the use of purely nitrogenous manures, it may be of interest to observe that over the three years of the experiments with sugar-beet, the increased production of sugar per acre per annum was about 20 cwts. by the use of 82 lbs. of nitrogen per acre per annum as ammonia-salts, and about 28 cwts. by the use of 82 lbs. of nitrogen as nitrate of soda.

It is then our characteristically starch and sugar-producing crops that are the most characteristically benefited by the application of nitrogenous manures; while our highly nitrogenous leguminous crops are comparatively little benefited by such manures.

Proportion of nitrogen of manure got back by the increase of crops.—But now let us consider what is the proportion of the nitrogen supplied in manure that we get back in the increase of the crops that are most specially benefited by its use?

In Table IX is shown the amount of nitrogen recovered, and the amount not recovered, in the increase of crops for 100 supplied in manure, to wheat, and to barley, respectively; the result being in each case the average over a period of twenty years.

TABLE IX.—*Nitrogen recovered, and not recovered, in the increase of Produce, for 100 supplied in Manure.*

Manuring, quantities per acre, per annum.	For 100 Nitrogen in Manure.	
	Recovered in Incr'se.	Not Recovered in Incr'se.
Wheat 20 *years*, 1852–1871.		
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	32·4	67·6
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	32·9	67·1
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	45·3	54·7
Barley 20 *years*, 1852–1871.		
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	48·1	51·9

Speaking generally, it may be said that, nothwithstanding the great effects produced by the nitrogenous manures, two-thirds of the nitrogen supplied were unrecovered in the increase of crop when the ammonia-salts were applied to wheat; the application being made in the autumn. When, however, nitrate of soda was used, which is always applied in the spring, the quantity left unrecovered was not much more than half that supplied. With barley also, the manuring for which takes place in the spring, there is again nearly half the nitrogen supplied in the manure recovered in the increase, and therefore little more than half left unrecovered.

It may be observed that, in the case of root-crops, when the supply of nitrogen is not excessive, the proportion of the nitrogen of the manure recovered in the increase may be much greater than in the case of the cereals; while in the case of the Leguminosæ the effects of such direct application of soluble nitrogenous manures to the surface soil is comparatively so small, and so uncertain, that it would be useless to give an estimate of the amounts recovered and not recovered respectively.

But what becomes of the one-half or two-thirds of the nitrogen supplied for the increased growth of the cereals, but not recovered in the increase of crop? Dr. Frankland and Dr. Voelcker have made numerous analyses of the drainage water from the experimental wheat plots which have yielded the results above referred to, and a summary of their results is given in Table X.

TABLE X.—*Nitrogen as Nitrates and Nitrites, per* 100,000 *parts of Drainage Water from Plots differently manured, in the Experimental Wheat Field at Rothamsted, Wheat every year, commencing* 1844.

Manuring, Quantities per acre, per annum.	Nitrogen as Nitrates and Nitrites, per 100,000 parts Drainage Water.					
	Dr. Frankland's Results.		Dr. Voelcker's Results.		Mean.	
	Experiments.		Experiments.		Experiments.	
Farm-yard Manure	4	0·922	2	1·606	6	1·264
Without Manure	6	0·316	5	0·390	11	0·353
Complex Mineral Manure	6	0·349	5	0·506	11	0·428
Complex Min. Man. and 41 lbs. nitrogen, as ammonia	6	0·793	5	0·853	11	0·823
Complex Min. Man. and 82 lbs. nitrogen, as ammonia	6	1·477	5	1·400	11	1·439
Complex Min. Man. and 123 lbs. nitrogen, as ammonia	6	1·951	5	1·679	11	1·815
Complex Min. Man. and 82 lbs. nitrogen, as nitrate	5	1·039	6	1·836	10	1·437

The figures in the Table conclusively show that the quantity of nitrogen as nitrates per 100,000 parts of the drainage water, increased in very direct proportion to the increase in the amount of ammonia or nitrate supplied, and it is obvious that there has been a considerable loss of the nitrogen of the manures by drainage. But as the subsoil rests upon chalk not many feet below the surface, and there is, therefore, natural drainage constantly going on, even when there is no flow from the pipes, it is impossible accurately to estimate the total amount of drainage, and therefrom the total amount of loss. Other experiments at Rothamsted, however, lead to the conclusion that, according to season, from one-quarter to nearly one-half of the annual rainfall may pass below 40 inches. Now, supposing drainage water to contain one part of nitrogen as nitrates per 100,000 parts of water, an inch of rain passing beyond the reach of the roots would carry with it 2¼ lbs. of nitrogen per acre; and it is obvious that if from seven to ten inches passed annually of that average strength, the loss would be very great. In reference to this point it is of much interest to observe, that in the Report of the River's Pollution Commission already referred to, Dr. Frankland gives a series of analyses of land drainage waters collected at Rothamsted, at depths of twenty, forty, and sixty inches, respectively; and those collected at twenty inches, almost invariably show much more nitrogen as nitric acid than those taken at either forty or sixty inches. It would thus appear to be indicated that a considerable amount of nitric acid has been arrested in the soil below the depth of twenty inches. Further, determinations of nitrogen in the soils do show some accumulation. Indeed, it would appear probable, that the whole of the nitrogen applied to the wheat as ammonia salts or nitrate of soda, was either recovered in the increase of crop, or may be accounted for by determinable accumulation within the soil, or by loss by drainage.

In ordinary agriculture, the amounts of soluble nitrogenous manures applied would generally be much less than in some of these special experiments; and the losses by drainage would from that cause alone be proportionately less than that shown above. Much, obviously, would also depend upon the character of the soil and of the subsoil. Again, in an ordinary rotation of crops, more of the supplied nitrogen would probably be gathered up before it reached the lower layers, than in the case of a cereal crop grown year after year on the same land. It may be safely concluded, however, that whenever cereals were grown, a material proportion of the nitrogen specially applied to, or existing in the soil, which would be available to other crops, would not be so to them; but would in the first instance accumulate in the surface soil, and gradually pass into the lower layers in the form of nitrates, to be eventually lost by drainage if not arrested by some other crop.

The question obviously arises, whether we have not here a source of some at least of the nitrogen available to leguminous or to other plants having possession by their roots of a greater range of subsoil than the Gramineæ. We have evidence enough that although wheat and barley send roots down very deep into the subsoil, and pump up moisture from the deeper layers, they nevertheless derive much of their nitrogen within the surface soil. If the Leguminosæ do not so readily do so, or at any rate naturally depend more upon the nitrogen in the lower layers for a considerable proportion of that which they require, and moreover are able to avail themselves of the residue from the manuring for other crops, what is the nature of the problem that we may have to solve to elucidate this point?

By way of illustration it may be mentioned that, supposing a leguminous crop to acquire 100 lbs. of nitrogen per acre from a layer of subsoil three feet in thickness, weighing approximately 10,000,000 lbs. (exclusive of stones and water), this would represent only ·001 per cent of nitrogen so acquired in such subsoil; 200 lbs. of nitrogen per acre so available would represent ·002 per cent, and so on. Now, even supposing that the nitrogen existed in the subsoil in such a condition as to be converted into ammonia in the process of combustion with soda-lime, the difference between one subsoil containing this, or even a larger amount of nitrogen, more than another, could not with certainty be determined by that process; for, in taking say 15 or 20 grams of the subsoil for combustion, the difference between two or more determinations could not be expected to be less than some units in the third decimal place (per cent); that is, in fact, equal to the total amount that may be in question as between two subsoils to be compared. Further, if this available nitrogen exist in the subsoil as nitrates, it may be a question whether there would be a sufficient amount of organic matter present to insure the evolution as ammonia of the nitrogen of the nitric acid.

It has been shown, then, that there are many questions still open for investigation in regard to the relations of the surface soil to combined nitrogen; and there are obviously also equally important points to investigate in regard to the nitrogen of the subsoil, before we can hope to arrive at a satisfactory solution of some of the problems which the consideration of the facts of vegetable production which have been adduced, suggest for enquiry. Nor are the problems still open connected with the amount, and the condition, of the mineral food of plants within the soil, either few, or without special, and independent interest. And although those relating to the nitrogen seem to call for the first attention, the marked effects, so far, of potash manures, in increasing the amount of nitrogen assimilated over a given area by the Leguminosæ, seem to indicate the probability that even the difficulties connected with the sources of the nitrogen of our crops may not be solved without further knowledge as to the required conditions, or the actions, of the incombustible or mineral constituents in soils.

More extended investigation required.—Our results in regard to the variations in the amount of nitrogen in the soils and subsoils of our different experimental plots, obtained by the soda-lime process, together with the results already referred to, relating to the composition of the drainage water from plots variously manured, as well as others of quite a different kind, have shown the absolute necessity for an extended investigation of the soil question by more exact methods; and Mr. Warington is about to devote, probably some years, to this enquiry at Rothamsted. It is proposed that the questions relating to the nitrogen in subsoils should be the first considered, since, if the results do throw light upon some of the points at present in doubt, a definite step in advance will be so gained; and should they not do so, the ground will thus be cleared of certain obvious suppositions, and the course of further research will be the more clearly indicated. But if the amount of nitrogen to be discriminated should prove to be represented by only units in the third decimal place per cent, say ·002 for example, it is obvious that to get as little as four milligrams involved in the analysis. 200 grams of soil would have to be operated upon. The difficulties of the problem are thus sufficiently obvious. But, by the aid of the processes of water and gas analysis which have been explained by the President in his opening address, there is little doubt that they can be overcome, at any rate so far as the nitrogen existing as nitric acid is concerned; and by the kindness of Dr. Frankland, Mr. Warington is at the present time gaining experience in the use of those methods, in the laboratory of the College of Chemistry, before entering upon this special investigation at Rothamsted.

But even supposing we arrive at a satisfactory solution of the, at present, unsettled points in regard to the sources of the nitrogen yielded in agricultural production, when, as in the experiments to which attention has been directed, we have a soil to work upon which already contains accumulations of combined nitrogen amounting to several thousands of pounds per acre within the range of the roots of our crops, further questions in regard to the nitrogen may still be left open, namely,—to what actions a large proportion of the existing combined nitrogen may be attributed; and what in particular is the exact source of the accumulations of it in our soils and subsoils? And here it may be observed, in passing, that determinations made at Rothamsted have shown approximately the same percentage of nitrogen in the Oxford-clay obtained in the recent Sub-Wealden exploration boring at a depth of 500 and 600 feet, and in the subsoil at Rothamsted, taken a depth of about 4 feet only.

It is not within the scope of the present discourse to discuss fully what is known of the actual or possible sources of the already existing combined nitrogen, the special object of the enquiry being, as intimated at the commencement, to bring to view the facts relating to the yield of nitrogen in agricultural production, which the extended period of the investigations of Mr. Lawes and myself have enabled us to establish, and to point out the relation of this to the various known or supposed sources of present periodic supplies, so as to indicate what points seem the most urgently to demand further investigation. In the papers already referred to, we have more fully considered what was known of the various actual or possible sources of the combined nitrogen which we know to exist, and to circulate, in land and water, in animal and vegetable life, and in the atmosphere, and we have pointed out how little was established of either the actual or the relative importance, in a *quantitative* sense, of the various actions by which it is admitted that free nitrogen may in nature be brought into combination. I may, however, observe that M. Boussingault and M. Schlösing have quite recently made interesting contributions to the discussion of this subject. (Compt. Rend., t. lxxvi, lxxx, lxxxi, and lxxxii).

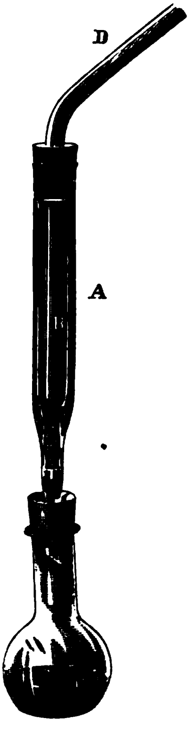
But whatever may be the origin of the existing combined nitrogen, or whether or not the agencies of its formation are more or less active now than during the earlier history of the earth and its atmosphere, the question arises whether, assuming the origin to be independent of the direct action of vegetation, the large accumulations within our soils and subsoils, admits of any reasonable explanation? On this point it may be remarked, that ages of forest growth, or of the growth of natural herbage only grazed by animals, would doubtless leave the soil richer year by year; as the amount annually lost to it would probably be less than even the small amount known to be annually deposited from the atmosphere, in temperate regions, at the present time; and the accumulation would probably be greater still, were the amounts of combined nitrogen in the atmosphere, and brought down from it, greater than with us at the present time. Then, again, the influence on aqueous deposits of ages of submarine vegetation, and of the subsistence of animal life upon it, has to be considered. But a soil once broken up, and under arable culture, it is difficult to conceive of any system of agriculture by which so little nitrogen as that hitherto quantitatively determined to be annually deposited from the atmosphere would be annually exported from the land.

Conclusion.—And now, to summarize in a few words the results of the whole discussion, I think the balance of the evidence points to the conclusion, that the answer to the question—what are the sources of the nitrogen of vegetation in general, and of agricultural productions in particular, is more likely to be found in the relations of the atmosphere, and of the plant, to the soil, than in those of the atmosphere to the plant itself.

One word more in conclusion. I have, as explained at the outset, confined attention almost exclusively to one aspect of the great subject of vegetation; but it will not be supposed that I have done so from any want of appreciation of the interest and importance of other lines of inquiry; and allow me, before closing to allude to a point which can hardly fail to suggest itself on an inspection of the numerous organic compounds, made by transformation in the laboratory, which are collected in the Chemical Section of this Exhibition. Without in the least degree disparaging such work, I would ask whether some of those who have become masters of such transformations, might not with advantage, armed with the experience thus gained, now devote themselves to the study of the transformations going on within the plant and the animal? In other words, whether it would not be desirable, that some of the thought and labor now expended on transformations in the chemical laboratory should be transferred to the laboratory of nature?

ART. XXII.—*Apparatus for quantitative Fat-extraction; On the Composition of the Sweet Potato; On the Composition of Maize Fodder*; by S. W. JOHNSON.—*Contributions from the Sheffield Laboratory of Yale College.** No. XLIII.

I. *Apparatus for quantitative Fat-extraction.*



THE apparatus consists of a glass tube A, of $\frac{3}{4}$ to $\frac{7}{8}$ in. bore and 6 to 7 in. long, narrowed at bottom to a bore of $\frac{1}{4}$ in., and there fitted by a cork to a flask C, of 80 c. c. capacity, and connected above by a cork with a reversed Liebig's condenser D. Within A a similar but smaller tube B is maintained free from the sides of the larger tube, either by three knobs of glass fused upon it where it begins to narrow, by a support of platinum foil as in the figure, or by suspension with help of a wire looped around the upper part of B and a hook depending from the cork above it. B is closed below either by a plug of cotton or asbestus or else by a disk of filter paper supported by one of muslin tied over its narrow and slightly flanged end. The substance to be extracted is introduced into B, 50 c. c. of ether or other solvent are placed in the flask and heat is applied to boil the liquid. Its vapor passes into the condenser, and there liquefies; the liquid drops continuously upon, and percolates the contents of B, carrying into C any dissolved matters, whence it rises again as vapor to be again condensed and repeat the solvent action.

The cooling must be effectual and the heat applied to the flask just sufficient to maintain a regular circulation of the solvent. B may be weighed with its contents, after closing the end by means of corks or rubber caps. To dry its contents it may be connected at one end by means of a perforated stopper and tube to an apparatus for supplying pure hydrogen, at the other by a rubber tube several inches long and $CaCl_2$ tube to an aspirator, and may be heated by immersion in an inclined position in a bath of boiling water, while a slow stream of dry gas is transmitted. The loss in weight of B and its dried contents may in some cases give the amount of oil extracted more speedily and accurately than direct weighing of the latter. For ordinary quantitative fat-estimations A and B may be made from stout test tubes.

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* The substance of these papers was read at the Detroit meeting of the American Association for the Advancement of Science, in August, 1875.

This apparatus is not only easier to construct and to handle than those which have a separate interior or exterior tube to carry up the ether-vapors, but has the additional advantage that the substance to be extracted is kept warm by being constantly surrounded with hot vapor.

It is best to mount the apparatus so that it may be put into a somewhat inclined position if needful, as then by revolving the apparatus on the condenser tube D the stream of condensed solvent may be directed in succession on all parts of the contents of B and any channels that may form are easily broken up.

In milk-analyses I have followed the fat-extraction by similar treatment with 80 per cent alcohol for the separation of sugar.

II. *On the Composition of the Sweet Potato.*

The Sweet Potato (*Convolvulus batatas* or *Batatas edulis*) is an esculent of great value to the United States. It is not only at home in all the Southern States, but is produced in large quantities in Central New Jersey, and Central Illinois, latitude 40°; and has been successfully raised in gardens in nearly the coldest parts of New York, as well as in Maine and Southern Minnesota (St. Paul), in latitude 44° to 45°. It is probable that under northern cultivation varieties may originate more adapted to cold climates, so that were it needful its profitable cultivation might be extended several degrees of latitude northward, as is said to have happened in Europe with regard to maize, for which it is asserted that 46° north latitude was formerly the limit, whereas now it is cultivated nearly to 52°.

The Sweet Potato is known in many varieties which differ widely in quality. Naturally, the kinds which are propagated at the north are less sweet and less highly flavored than those produced in a warmer climate. The New Jersey and Delaware sweet potatoes which are marketed in New England, though palatable and largely consumed, are decidedly inferior to the produce of Virginia. I am informed that sweet potatoes of excellent quality are raised in Southern Illinois, lat. 37°–38°, while those produced in Central Illinois, lat. 40°, are "watery" and comparatively insipid.

The sweet potato in highest repute at the north is the Nansemond, taking its name from the southeastern county of Virginia, where it is said to have originated. The "Nansemond Improved," raised in Hanover Co., Va., is the finest variety of this esculent that has come under my notice. I am indebted to John Ott, Esq., of Richmond, Va., for abundant samples of this variety, the high quality of which has induced me to undertake its analysis.

The composition of the sweet potato has been studied by Proust, Einhof, Payen, Henry, Fromberg, and Antisell.

Their analyses were mostly made by methods less perfect than those we now possess, and they differ from each other to a degree not explained by the variations in quality of the sweet potato itself, and some of them are evidently incorrect. Since there is to my knowledge no printed summary of these older analyses I have thought it worth while to reproduce them.

As chemists are too well aware, no unexceptionable methods for separating or estimating some of the organic principles of our esculents have as yet been discovered. Since the tendency of newer researches points to the existence in plants of a series of isomeric bodies with the denser and maturer forms of cellulose at one extremity and dextrin at the other, with various celluloses, starches, amylodextrins and dextrins intermediate, which defy separation and have long resisted identification, the best that can be done in proximate analysis is to follow some method conventionally agreed upon, by which fairly comparable results may be reached. The analysis of the "Nansemond Improved" was made essentially according to the plan adopted by the German Agricultural Experiment Stations, and the results have been for the most part verified by repetition and critical examination of the educts. This analysis has regard only to the more important food-principles, without reference to traces of malic acid, etc., which have been reported in former examinations.

For analysis, about 600 grams of the tubers were thinly sliced (in December, 1874), air-dried in a warm room and then pulverized. In 5 grams of air-dry substance, water was estimated by three methods.

1. By drying at 100° C. in a flask exhausted by the Bunsen-Sprengel pump. This method, which leads speedily to the desired result in case of other vegetable matters, e. g., maize-meal, hay, etc., required several days for bringing sweet-potato flour to a constant weight.
2. By drying in air-bath at 125° C. This process speedily removes the water but occasioned browning of the substance.
3. By drying at 100° in a stream of hydrogen, a method somewhat tedious but less so than 1, and now adopted by many of the German Experiment Stations.

The three methods gave of loss on air-dry substance:

1		7·19 per cent.
2		6·90 " 7·13 "
3		7·54 " 7·19 "
	Average =	7·19 "

The total loss of *water* experienced by the fresh substance = 73·39 per cent.

Fat was extracted from the dried-residue of the water-estimation, by treatment with carbon disulphide in the apparatus before described. The process required twelve hours for completion. Two trials yielded 0·26 and 0·31 of a soft yellow substance, appearing at first like a pure fat, but which to the feel and taste had more of the properties of wax than of the ordinary fats. It probably resides chiefly in the laticiferous tissue, whose yellow juice is evident on a fresh section of the sweet potato.

An aqueous extract of the sweet potato was obtained by digesting four grms. of finely-pulverized air dry substance with nearly half a liter of cold water for five hours and filtering. The residue was treated with a similar quantity of cold water for twelve hours more. Aliquot portions of the two extracts were separately evaporated in capsules and dried at 212° F. The first extraction was practically complete, as the second digestion took up but 3·5 mgr., or a little more than $\frac{1}{10}$ per cent of soluble matters. The total amount of solid aqueous extract, after deducting ash, was 7·94 per cent.

The aqueous extract was brown in color and perfectly clear. Boiled, it gave a very slight precipitate, acids made it turbid, and Millon's test gave a faint red tint to the liquid on heating. Iodine gave no coloration. Basic lead acetate gave a copious precipitate, separating in flocks on boiling, and in the filtrate Fehling's solution gave reddish-yellow precipitate on boiling. These reactions indicate presence of a trace of albuminoids, of gum* and of a glucose. They exclude starch, amylodextrin and dextrin.†

To effect proximate separation of gum and sugar, a portion of aqueous extract was evaporated to dryness, taken up in a very little water and treated with 80 per cent alcohol. Sugar was recovered by evaporation of the alcohol solution. As is known, this separation is a rough one. The sugar obtained gave on boiling with Fehling's solution, at once, a copious flocky-red precipitate. Set aside in concentrated solution it showed no signs of crystallization. It therefore largely consisted of a *glucose*. Its amount was 6·86 per cent. The substance remaining insoluble after a second treatment with alcohol, which was mostly *gum*, was 1·08 per cent of the fresh tuber.

Cellulose was determined by alternate treatment of the powdered substance with dilute (2 per cent) sulphuric acid and caustic soda solution, in the usual manner. Combustion, with the mixture of equal bulks of sodium carbonate and slacked lime, gave 0·187 and 0·207 per cent of nitrogen, which multiplied by 6·25 leads to the content of *albuminoids.* Starch was estimated by difference. The summing up is as follows:

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* The term gum is used in a generic sense. The substance obtained appeared to have more nearly the characters of arabin than of pectin or other gummy body, being highly soluble in water.

† See Nägeli, Beiträge zür näheren Kentnisse der Stärkegruppe, p. 103.

Water	73·39
Starch, by difference	15·06
Gum	1·08
Sugar (levulose?)	6·86
Cellulose	0·98
Albuminoids	1·28
Fat and wax	·28
Ash	1·07
	100·00

Table I includes all the analyses of the sweet potato that I have been able to find.

In the older analyses, 1 to 6, the figures for starch and cellulose are of no value because they were the results of an attempted mechanical separation. In fact these analyses are worthless for any purpose, except as regards the water and sugar estimations. Fromberg's figures for water are too exceptional to have any claim to accuracy.

As already mentioned, the figures in analyses 6 and 7 are so coincident in regard to several ingredients, and so plainly wrong in 6, as respects ash, that they must both be considered untrustworthy. Whether the low amounts of water in 8, and of sugar in 9, and the high percentages of sugar in 8 and of starch in 9, are analytical errors or characterize the sweet potato in its different varieties, remains to be established by future comparative investigations.

In the common potato (*Solanum tuberosum*) a range of water content from 68 3 to 82·1 per cent, and of starch-content from 15 to 26 per cent has been observed.

In nutritive values the Hanover sweet potato and the common potato on the average differ but little. Their comparative composition is as follows:

	Sweet potato.	Potato.
Water	73·4	74·6
Albuminoids	1·3	2·2
Fat and wax	0·3	0·2
Carbohydrates	23·0	21·2
Fiber	1·0	0·7
Ash	1·0	1·1
	100·0	100·0

The average composition of the common potato is that given by Dietrich and König in their *Zusammensetzung und Verdaulichkeit der Futterstoffe.*

TABLE I.

	1 Proust. Malaga. Gasparin, Cours d'Agriculture, t. iv, p. 58.	2 Einhof. ? Ure's Dict. of Arts, Am. ed., article Potato.	3 Henry. France ? Liebig's Handwörterbuch, 2d ed., 2 Bd., 1 Abth., article Batate.	4 Fromberg. Barbadoes. Johnston's Lect. on Ag. Chem., 2d Edinboro ed., p. 909.	5 Payen. Neuilly ? White ? Hamm's Landwirthschaft, Bd. 2, p. 165.	6 Payen. France ? Payen et Richard, Precis d'Agriculture.	7 Payen. France ? Yellow (Yam ?)[12] Deherain, Chimie Agricole, p. 159. Pelouze et Fremy, Cours de Chimie, 2d ed., t. vi, pp. 292–3.	8 Payen. France ? Red.	9 Antisell. N. Orleans. Report of Dept. of Agricult're, 1869, p. 75.	10 Johnson. Hanover Co., Va. Yellow Nansemond
Water	72·0	74·3	73·1	59·31	71·25	74·00	79·64	67·50	73·00[14]	73·39
Starch	9·5	15·1	13·3	16·62	17·00	9·42	9·42[13]	16·05	19·16	15·06[15]
Cellulose	14·5[1]	8·2	6·8	12·88[4]	8·55[7]	2·54	0·54	0·45	1·98	0·98
Gum	----	----	----	0·55[5]	----	1·30[9]	1·30[9]	1·10[9]	----	1·08
Cane Sugar	4·0[2]	----	3·3	7·99	3·20	1·45	3·50	10·20	4·35	----
Grape Sugar	----	----				1·04			----	6·86
Albuminoids	----	0·8	0·9	2·66[6]	----[8]	1·10	1·10	1·50	0·35	1·28
Fat (wax)	----	----	1·1	----	----	0·89	0·25	0·30	0·24	0·28
Ash	----	----	----	----	----	13·69[10]	3·25	2·90	0·92	1·07
Total	100·00	98·4	99·9[3]	100·01	100·00	105·43[11]	99·00	100·00	100·00	100·00

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[1] With starch, "parenchyme amidonne."

[2] "Matter soluble in water."

[3] Including "1·4 % malic acid."

[4] "With a little oil and coagulated albumin."

[5] "Dextrin."

[6] "Impure caseine." By estimation of nitrogen, Fromberg calculated 2·27 % albuminoids.

[7] Given as "fibrine" obviously a mistake for "fibre."

[8] Nitrogen is given at 0·199 %, equal to 1·25 albuminoids.

[9] "Pectic acid with organic matter."

[10] Includes 6·48 % salts and 7·00 malates of potash and ammonia, as quoted by Gasparin, Cours d'Agriculture, p. 59. Sacc, Cours de Chim. Agricole, gives water 7·3 % and 'salts and malates' 9·26.

[11] The total is given by Payen and Richard as 103·43.

[12] Deherain gives this as an analysis of the "Batate (Convolvulus batatas)," Pelouze and Fremy as an analysis of the yellow yam, "Igname jaune."

[13] The correspondence of the figures for starch, gum, albuminoids and cellulose between this and the preceding analysis, and the excess of 5·43 % in 6, indicate some confusion which I cannot unravel.

[14] Antisell analyzed "sweet potato flour" containing 7·95 % water. He calculated the composition of the sweet potato fresh, assuming 65·96 % water. I have calculated the results of his analysis on 73· % water, for the sake of better comparison.

[15] Estimated by difference.

The sweet potato is possibly more easily digestible than the common potato, because of containing nearly 7 per cent of soluble sugar in place of a similar amount of starch. Its sweet taste is mentioned by European writers as a reason why it does not enter more largely into the produce of southern France, and probably for most inhabitants of temperate regions it does not relish so well in constant use as does the common potato, which, like bread, appears daily and twice daily on the tables of the Middle and New England States, as well as on those of England, Germany and France. The sweet potato is, however, in its best varieties a most inviting esculent, and perhaps "wears" better than any other vegetable save the common potato. Its juices are so rich in sugar that the tuber keeps poorly, for wherever the cuticle is broken, the common omnipresent fungi take root, under favorable conditions of temperature and moisture, and rapidly penetrate the tissues, producing discoloration and dry or wet rot. French authorities report that the potato-fungus, *Peronospora infestans*, attacks the sweet potato as vigorously as the common.

III. *On the Composition of Maize Fodder.*

The use of maize as a fodder plant is very extensively practiced in this country as well as in South Germany and Austria. In the latter countries maize fodder appears to be uniformly regarded as a valuable resource to the farmer. In the United States, however, some excellent farmers have denounced it for various reasons; some because of the difficulty of securing the crop, and others because of its supposed innutritious quality. In fact, chemical analysis has been employed to show that maize is a comparatively worthless fodder crop.

These considerations induced me to undertake its investigation, and I have been fortunate in finding highly suitable material on the farm of J. J. Webb, Esq., near New Haven, Conn., as well as the most hearty assistance in preparing the fodder for analysis at the hands of that gentleman. Two samples, raised from separate plantings and on separate fields, were placed at my disposal. The variety of maize was the Southern or Norfolk White; the seed was obtained from Long Island. No. 1 was raised on long tilled ground and inverted sod, with help of stable manure. No. 2 was taken from new ground, which had borne two rye crops, was seeded, had been in pasture for five years, was then plowed and had carried two successive crops of corn fodder, of which it was of course the last. To the soil that yielded No. 2 no stable manure had ever been applied. No. 2 was sown 10 to 15 days earlier than No. 1, and was more mature at the time of cutting the samples, Sept. 1st, 1874.

In planting, three bushels of seed were sown per acre, in drills 24 inches apart. When harvested the stalks had an average height of 10–12 feet. Many stalks measured 14 feet in length. Their diameter was very uniform, rarely more than $\frac{11}{16}$ inch at the base.

The corn thus planted and growing under clean tillage was so mature and uniform that it admitted of easy and perfect curing, and yet at the same time was so tender and palatable that little or no loss occurred in feeding. When harvested the corn-fodder contained a good many imperfectly developed ears, some of them with nearly ripe kernels.

The corn on cutting was set up in the field in large carefully made stooks, where it remained until Nov. 11, when it was removed to the barn in good order. The samples were obtained by cutting off in each case an area of 10 feet square, including 5 rows and a length of 10 feet on each row.

The stand of the crop was so uniform, both horizontally and vertically, as to ensure a very accurate result in sampling.

Each sample was made into bundles which were at once weighed, labeled and set up in the field as parts of a stook. When the crop was housed the samples were again weighed. They remained in the barn until February, 1875, when the use of corn-fodder began for the winter. They were again weighed on February 8th, and immediately were run separately through a straw-cutting machine, which reduced them to half an inch lengths, and in that state were brought to the laboratory.

Each sample was then carefully intermixed and weighed portions were taken for analysis. The portions were reduced to tolerable fineness by passing repeatedly through a sausage-cutter and by the use of shears, and for the nitrogen estimations were further pulverized by triturating with purified quartz sand. The proximate analysis for water and cellulose was conducted as mentioned in the previous paper. "Ether extract" was obtained by the extraction apparatus already described. Ash was determined by incineration at a dull red heat in a platinum dish.

The results of the analyses, calculated upon the material in the different stages of dryness in which it was weighed, are the following:

	Fresh cut. Sept. 1, 1874.		Field-cured. Nov. 11, 1874.		In Barn. Feb. 10, 1875.		Dried. Water-free.	
	1	2	1	2	1	2	1	2
Water	87·18	85·04	27·59	26·92	53·76	54·95		
Ash	0·84	0·74	4·76	3·62	3·04	2·24	6·57	4·95
Albuminoids	0·88	0·78	4·97	3·79	3·18	2·34	6·87	5·19
Fat, etc., (ether extract)	0·28	0·22	1·55	1·07	0·99	0·66	2·14	1·46
Cellulose (crude)	4·38	5·16	24·76	25·18	15·81	15·52	34·19	34·45
Carbohydrates, etc., by difference	6·44	8·06	36·37	39·42	23·22	24.29	50·23	53·95
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The further examination consisted in extracting the pulverized fodder with water, evaporating the solution, to determine total quantity of soluble matters, redissolving in a little water and treating with 80 per cent alcohol to throw down gum.

This treatment was carried out both with cold and hot water. The results were as follows, calculated on dry substance:

	1 Water.		2 Water.	
	Cold.	Hot.	Cold.	Hot.
Total extract	1·49	22·27	2·01	26·54
Ash	·47	5·21	·31	4·41
Soluble in alcohol, starch, sugar, fat, etc.,	·80	10·87	1·48	21·51
Insoluble in alcohol, gum	·22	6·16	·22	·62

The water extract gave a reaction with Fehling's solution, showing the presence of a little sugar. The alcohol precipitate when redissolved in water gave no reaction with Fehling's solution but contained a trace of albuminoid.

Starch is carried into solution by boiling with water, and soluble gum is more completely extracted by the hot maceration of the imperfectly pulverized material.

These laborious trials were not duplicated, and it is not fully established whether the absence of gum in 2 is the result of a possible error in analysis or the consequence of maturer development of stalks. The larger quantity of hot water extract in 2 is not improbably due to the presence of seed kernels with abundant starch.

The results agree fairly with the average of a number of analyses made of late years in Germany and Austria, which, however, doubtless refer usually to a much smaller plant and crop.

The subjoined statement gives: A, the average of my two analyses; B, the average of the German analyses as given by Wolff, Fütterungslehre, 1874; C, the average given by Dietrich and König, 1874. All refer to the fresh fodder.

	A.	B.	C.
Water	86·1	82·2	85·0
Ash	0·8	1·1	1·0
Albuminoid	0·8	1·2	1·8
Ether extract (fat and wax)	0·3	0·5	0·6
Cellulose	4·8	4·7	4·4
Carbohydrates, etc.	7·2	10·3	7·2
	100·00	100·00	100·00

Total Yield.—The following figures give the gross produce of the two crops upon an area of 100 square feet as ascertained by Mr. Webb's weighings, and also the produce, per acre, (found by multiplying these weighings by $\frac{43560}{100}$) as well as the quantities of water and dry matter in the fodder at the several times of weighing.

	Crop 1.			Crop 2.		
	100 sq. ft.	1 Acre.		100 sq. ft.	1 Acre.	
	lbs. oz.	lbs.	tons.	lbs. oz.	lbs.	tons.
Fresh cut, Sept. 1	124–4	54,123	27	117–4	51,074	25 5-10
Containing water	108–5*	47,184	23 1-2	99–11*	43,413	21 7-10
Field-cured, Nov. 11	22	9,583	4 8-10	24	10,454	5 2-10
Water	6–1*	2,644	1 3-10	6–7*	2,793	1 4-10
In barn, Feb. 8	34–7	15,028	7 1-2	38–15	16,988	8 5-10
Water	18–8*	8,089	4	21–6*	9,327	4 7-10
Dry	15–15†	6,939	3 1-2	17–9‡	7,661	3 8-10

Werner, Handbuch des Futterbaues, p. 602, gives the yield of uncured maize fodder in Germany and Austria in four instances, as follows: 50,000, 72,000, 72,000 and 52,800, or an average of 60,000 kilos. per hectare. This average equals 53,440 lbs. per acre. One of the crops of 72,000 kilos. equal to 64,129 lbs. per acre, made 14,000 kilos. of cured fodder, "maize hay," equal to 12,470 lbs. per acre. The loss of water in curing was 80½ per cent of the fresh cut maize. This indicates that the crop was thickly sown, probably on very rich ground, and was cut in a quite immature and watery state.

It is noticeable that the less mature crop 1, weighed fresh 1½ tons more than 2, but when field-cured 2 was 870 lbs. heavier than 1. Crop 2, field-cured, contained 1½ per cent more water and also 3 per cent more carbohydrates, etc., than 1. The autumn weather during which the fodder stood in the field was exceptionally fine and dry. After storing, the weather of the winter was very rainy and damp, and for that reason the loosely packed fodder gathered moisture, so that the average 5 tons of fodder as it was stored Nov. 11, became 8 tons as it lay in the barn Feb. 8, after exposure for three months to the damp winter air. This gain of water was greatest with 2, amounting to more than 3½ tons for the produce of an acre, and being one-half as much water as the green fodder lost in field-curing, and as much as the field-cured fodder contained at the time of storing. Such variability in the water content of a harvested crop appears to be unexampled.

The objection urged against corn fodder that it is innutritious does not apply in respect to the *total yield* of dry matter, for to obtain $3\frac{65}{100}$ (average of 3½ and $3\frac{8}{10}$) tons per acre of dry matter from other forage, would require a crop of 4 tons of meadow hay, and 4¼ tons of clover hay, admitting these to contain 8 and 12 per cent of water respectively.

As respects nutritious *quality*, the corn fodder is very different from meadow or clover hay. To make the nature of the difference evident, I subjoin the average analyses of the dry matter of German hay and maize fodder,§ and an average of the two analyses of Mr. Webb's corn fodder.

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* Nearly.

† More exactly $15\frac{93}{100}$ lbs.

‡ More exactly $17\frac{54}{100}$.

§ From Dietrich & König's Zusammensetzung und Verdaulichkeit der Futterstoffe.

	German.			Mr. Webb's.
	Meadow hay.	Red clover.	Maize fodder.	Maize fodder.
Ash	7·7	7·4	6·7	5·8
Albuminoids—so-called flesh-formers	11·8	16·6	12·4	6·0
Fat	2·7	2·7	3·7	1·8
Cellulose—woody fiber	29·9	30·1	29·3	34·3
Carbohydrates, starch, gum, sugar, etc.	47·9	43·2	47·9	52·1

It is seen from the above figures that the German meadow hay and the German corn fodder are almost identical in composition. Clover hay differs from them in containing some four per cent more of albuminoid and four per cent less of carbohydrates. Mr. Webb's maize fodder contains but one-half as much albuminoids and fat as the German, while its cellulose and carbohydrates are each four to five per cent more. This difference between the two statements of maize fodder depends simply on the fact that most of the German analyses were made on less mature maize. Some of the German analyses give but 0·9 per cent of albuminoids in fresh fodder, the same result as in Mr. Webb's 1 (0·88).

How greatly age influences the content of albuminoids in forage plants is shown by the fact that meadow grass quite young as it is found in pasturage contains in its dry matter 24 per cent of albuminoids, cut just before bloom 12 per cent, and at end of blossoming but 8 per cent. In case of both maize fodder and meadow grass the inferior quality of the older vegetation is compensated by their superior quantity.

Such maize fodder as Mr. Webb produces is valuable when properly employed. Used as a substitute for meadow hay it would be pronounced, and deservedly so, poor cattle food, but as an ingredient of a properly compounded ration it has a high value. In New England, hay commands a high price in the cities and large towns, and is therefore adapted to sell off rather than to consume on the New England farm. The farmer can raise or buy Indian corn, cotton-seed meal, and other concentrated foods, and combine them with coarse fodder to make a cattle food equal or superior to the best of hay, at less cost than is involved in feeding the latter. To throw cured maize fodder out in the cattle yard or to feed it in the stall as hay is fed, is likely to be highly wasteful. To attempt to sustain cattle on it alone or to employ it as an adjunct to hay is also a mistake. To use it profitably it must be finely cut and well mixed or alternated with maize or cotton-seed meal, bran, or some similar material which serves at once to ensure its large consumption and the full economy of its nutritive qualities. Maize-meal and similar articles contain too much albuminoids, fat and starch, for healthy and economical cattle food. Maize fodder contains too little of these and too much coarse fiber. The mixing of the two in proper proportions enhances their separate value and makes a more perfect nutriment, and under New England circumstances doubtless an economical cattle food.

The digestibility of cellulose in the alimentary apparatus of herbivorous animals has not only been amply established by numerous feeding trials in the agricultural experiment stations of Germany and Austria, but the relative digestibility of the cellulose and other food-elements of various kinds of cattle food has been the subject of repeated experiments. The method of these investigations consists in determining by chemical analysis the amount of cellulose, etc., contained in the ingested food and the amount that passes off in the solid excreta. The difference is the quantity digested. It has been found as the average of some 45 experiments on oxen, cows, goats and sheep, that 62 per cent of the cellulose of meadow hay is dissolved in the digestion of these animals and serves as food, while as the average of 18 trials but 46½ per cent of the cellulose of red-clover hay is digested. In a single trial Moser found that 72 per cent of the cellulose of maize fodder was digested by sheep. One result is not conclusive as to the comparative digestibility of maize fodder, because this quality is influenced by the maturing of the plant, and by the individuality of the animal, as well as by the proportion of food-elements in the ration; but it indicates a high nutritive power.

Moser's results in regard to the other ingredients of maize fodder show that the sample he worked with was in all respects more digestible than the average meadow or clover hay, except these are cut before blossom, and was, roundly speaking, twice as digestible as the straw of the cereal grains.

I am indebted to my friend and late assistant, E. H. Jenkins, M. A., for carrying out the details of the foregoing analyses.

XXIII.—*On the Meteoric Stone of Rochester, Fulton County, Indiana;* by CHARLES UPHAM SHEPARD, Massachusetts Professor of Natural History in Amherst College.

A FALL of a meteoric stone took place at about 8:45 Thursday evening of the 21st of December, 1876. The circumstances connected therewith are drawn from several communications.* The first is from Professor Daniel Kirkwood, of Bloomington, Indiana, Professor of Mathematics in the Indiana State University, as published in the Indianapolis Journal. Professor Kirkwood's account says: "Last evening, Dec. 21, about 8:45 o'clock, our citizens witnessed a meteoric display of extraordinary brilliancy. A fire-ball, described by many observers as surpassing the moon in apparent magnitude, followed by a great number of smaller meteors, was seen in the northern heavens, moving in an easterly direction. Its first appearance was at a point 12° or 15° north of west, and about 10° above the horizon. Its greatest altitude, as seen from Bloomington, was about 18° or 20°, and its disappearance occurred at a point in the northeast, some 5° or 6° above the horizon. A remarkable feature of the meteoric group was the slowness of its apparent motion. The time of flight was variously estimated. Most observers, however, think it could not have been less than three minutes. Many of the meteors following in the train of the principal bolide were larger than Venus or Jupiter. No attempt was made to count them, but their number was certainly nearly one hundred. Some minutes after the disappearance a rumbling noise was heard, which was supposed to result from the meteor's explosion."

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* See also this volume, p. 166.

The second is from the Columbus (Ohio) State Journal.

"A meteoric display, which, for singularity and beauty, few persons in a lifetime have the good fortune to behold, was witnessed by six or seven persons, myself included, on the evening of the 21st inst., at just 9 o'clock. Four of us were in the caboose car, and two or three others on the engine of the freight train, due in Columbus at 9:20 P. M., on the Cleveland, Mount Vernon and Columbus Railroad, and within about four miles of the depot. At that point the track runs nearly north and south. The cluster or flock of meteors, from forty to sixty in number, varying in apparent size from a water-bucket down to the size of large apples, were seemingly huddled together like a flock of wild geese, and moved with about the same velocity and grace of regularity. The color of their light was a yellowish red, resembling the light from the red balls of fire thrown out by the explosion of some kinds of sky-rockets. There was no illumination, nimbus, or trail from them. The display was a little below an angle of 45 degrees from our point of observation, and seemed not over a quarter of a mile distant from the rear end of our train. The course was from west to east, crossing the railroad at nearly right angles. The party on our engine, and our conductor, who was looking out of the rear window of our car, made the discovery at about the same moment, in a westerly direction. When seen by the rest of us, the meteors were just passing over the track and very slowly approaching the earth. I cannot pretend to put this statement in scientific form, having witnessed it from a moving train, but simply state the facts as they appeared to myself and others as worthy of note."

The third notice attended one of the specimens sent me, and consists of a letter addressed to Professor Kirkwood, from Mr. A. J. Norris, the finder of this stone.

"Enclosed you will find a specimen of the meteorite. The circumstances under which the stone was found are these. Hearing a rumbling noise, I stepped out of the house, and heard the stone fall. I marked the direction of the sound, and the next morning repaired to the field whence it had proceeded, where I discovered it lying upon the snow. I saw two places where it had previously struck, and from whence it had bounded to its resting place. No appearance of any other stone was visible in the region. Its weight was about three-quarters of a pound."

The following is from a letter (dated Bloomington, Ind., Jan. 19th) from Professor Kirkwood to myself:

"You were kind enough to express a wish that I would furnish you some notes in regard to the meteor. I have written many letters of inquiry, to some of which I have received replies. I have also a number of newspaper accounts of the phenomenon. I regret to say, however, that many of the statements made by observers are so inaccurate and contradictory as to be of little value. Being busy with other matters, I placed nearly all of them in the hands of Professor Wylie. The following conclusions, derived from the observations at Bloomington, Indiana, and Wooster, Wayne County, Ohio, can be relied upon as nearly correct:

Rev. Dr. Wylie, Professor of Natural Philosophy in the Indiana State University, noticed the point in a tree apparently passed by the meteor. The angle of elevation was subsequently measured, and found to be about 15 degrees. But the meteor passed our meridian 131 miles north. These data, making allowance for the curvature of the earth's surface, give about 38 miles as the height of the body when passing the boundary line between Pulaski and Fulton Counties, Indiana. At Wooster, Wayne County, Ohio, the meteor apparently passed a particular point of the steeple of a public building. From this observation the apparent altitude when over Lake Erie, immediately north of the city, was found by Professor Samuel J. Kirkwood to have been about 24 degrees, corresponding to a true height of 28 or 29 miles.

The most western point from which I have received a report is Emporia, Kansas. It passed that place a few degrees S. E. of the zenith. I think the meteor became visible over the N. W. corner of Texas, at an elevation of 70 or 80 miles. The estimates of time for the meteor are so discordant that it seems impossible to determine whether it was moving in an ellipse, a parabola, or an hyperbola."

Description of the Rochester Stone.

It belongs, by way of eminence, to my order of Oolitic, of the class Litholites, and resembles most closely the Pegu (India) stone of December 27, 1857, particularly in the character of its crust and in its pisiform external structure. The two stones are not unlike in color and in the facility with which they may be broken, both yielding to separation when in small masses, under the mere strength of the fingers. The thickness of the crust in each is double that in the majority of litholites. The general tint of color is also the same in both. In the Rochester stone, however, the shade is less gray, from the greater prevalence of an almost pulverulent, nearly white mineral, in which the dark ash-gray globules are imbedded. This white mineral forms less than one-tenth of the mass. The globules vary in size from a millet-seed up to that of a pepper-corn. Their shape is almost perfectly spherical, and plainly indicates an origin from fusion, the surfaces of many of them being obviously mammillary, while internally they present a porcelainous, compact structure.

The globules are probably forsterite, of a variety nearly identical with boltonite. This appears the more likely from the circumstance that those situated just below the crust have the yellowish tint acquired by boltonite after its subjection to heat with access of air; and it is presumable that this alteration of the globules in the meteorite took place on its entrance into our atmosphere when the fusion of the surface occurred.

The white semi-pulverulent basis of the stone I take to be Chladnite ($\dot{\mathrm{M}}\mathrm{g}^2\mathrm{Si}^3$). In one of my specimens, it shows itself at a single point in its characteristic loosely crystalline structure; and there closely resembles this species as seen in the Bishopsville (March 25, 1843) meteorite.

The metallic iron (chamasite?), as in the Pegu stone, is very obvious; and rather evenly distributed, though probably not exceeding one per cent in quantity. In place of being in shapeless grains or points, or in curved wire-like fibers, it is semi-crystalline in structure, showing occasional rectangular and triangular facets. Troilite is barely visible at two minute points in the specimens thus far examined. Two distinct grains of Chrysolite, of the size of half a rice grain, are present, showing in each case the cleavage, color and luster of this species, as existing in Krasnojarsk meteoric iron. Moreover, these grains have not the perfect spherical form of the forsterite globules.

The specific gravity of a fragment, whose surface was one-third crust, is 3·65. It may be added in conclusion, that the inspection of this rather peculiar stone strongly suggests the idea that the pisiform globules were produced by the sudden fusion of what was originally a chladnitic material (similar to the Bishopsville stone), amid particles of chamasite attended by access of oxygen, whereby the silicate of magnesia became converted into the more fusible double silicate of magnesia and iron.

New Haven, Conn., Jan. 22, 1877.

Art. XXIV.—*Examination of the Waconda Meteoric Stone, Bates County Meteoric Iron and Rockingham County Meteoric Iron;* by J. Lawrence Smith, Louisville, Ky.

The meteorites under consideration have been known for some little time, Prof. C. U. Shepard having given a notice of the Waconda meteoric stone in this Journal of June, 1876, he having acquired the larger portion of it; the remainder has been kindly presented to me by G. W. Chapman.

The existence of the Bates County meteoric iron was announced by Prof. G. C. Broadhead (this Journal, Nov., 1875) to whom I am indebted for a large portion of the original mass.

Waconda Meteorite.

One feature to be noticed in connection with this meteoric stone is that the time of its fall is not known; it having been discovered in a ravine near the village of Waconda in Kansas (lat. 39° 20′, long. 98° 10′). While there are three or four of these softer meteoric stones, consisting almost exclusively of stony matter, the exact time of whose fall is not known, there is every reason to suppose that their falls were observed, and that they were collected at the time; but falling in remote places, and in the lands of those not accustomed to note precisely the dates of natural phenomena, the exact date of the fall was forgotten when it reached those who were interested in these bodies.

In the present instance nothing was known to lead to its discovery, and it was simply gathered up by an inhabitant of a sparsely settled region and laid aside on account of its singular appearance, and was only recognized as a meteorite some time afterward by one who had some knowledge of these bodies. Although but recently brought to notice, it was discovered two years ago, and I am inclined to believe that its discovery must have been made not very many months after its fall, as otherwise it would have undergone more thorough decomposition; as it is, the interior is marked with large blotches of oxide of iron arising from oxidation of the particles of iron by the water penetrating from without.

This exposure has doubtless had something to do with its friability as a whole, for many parts of it are quite firm where the iron is not oxidized, and, as Prof. Shepard says, it has the average cohesion of this class of meteoric stones. As he has already given a general description of it, I will not repeat it here, but proceed at once to give my chemical and mineral analyses.

The specific gravity of pieces from the interior varied from 3·4 to 3·6, and when separated mechanically consisted of—

Stony matter	90·81
Nickel iron	5·34
Troilite	3·85

The amount of the last mineral was made out by chemical analysis. The nickel iron contains:

Iron	86·18
Nickel	12·02
Cobalt	·91
Copper	·04
Phosphorus	not estimated.

The stony part treated with large excess of aqua regia gave:

Soluble part	69·00
Insoluble part	41·00

Composed of—

	Soluble.	Insoluble.
Silica	34·52	54·02
Protoxide of iron	30·01	18·10
Magnesia	32·50	23·45
Alumina	0·43	2·30
Manganese	·61	·36
Soda with trace of potash and lithia	·89	1·58
Lime		*trace*

The analysis clearly shows that the stony part of this meteorite consists of the usual mixture of olivine and pyroxene minerals; the hyalosiderite predominating in the former, and bronzite in the latter.

Two minerals were detached in small quantities and analyzed separately. The first was a dark colored mineral, readily seen in small parcels and veins; this, freed as far as possible from the adhering minerals, was found to be soluble in strong hydrochloric acid, and the prolonged action of this acid on the mineral, heated over the water bath, decomposed it very nearly completely; it is composed as follows:

Silica	41·10
Protoxide of iron	27·20
Magnesia	28·31
Alumina	·80
Manganese	·32
Soda	1·35

Its solubility in chlorhydric acid, and its composition, clearly point it out to be of the olivine type.

The other mineral was found only on one part of my specimens and there in the form of a white crystalline mass not exceeding in weight 20 milligrams; it looked at first sight like enstatite, but there was sufficient difference in its aspect to lead me to detach a few milligrams and test it; when I found it readily and completely soluble in hydrochloric acid, and as far as it was possible to decide on so minute a quantity it appeared to consist only of silica and magnesia.

Its solubility shows clearly that it is not enstatite, and I can only imagine it to be of the olivine type and consisting entirely of silica and magnesia, occupying the same place among the unisilicates of the meteorites that the enstatite does among the bisilicates. I simply note this fact here, not as giving any very definite result but simply that it may be looked into by those investigating these subjects.

Bates County Meteoric Iron.

This meteoric iron was first made known by a short note in this Journal, Nov., 1875, p. 401. It was discovered near Butler, in Bates County, Missouri (lat. 38° 20′, long. 94° 22′). The mass as it reached me had been in a blacksmith's forge, it having been heated for the purpose of cutting off a piece. It weighed about eighty pounds and was of an irregular form, with nearly equal diameters in all directions; it had a thick coat of rust on the surface; the metal is very tough and when cut across, numerous nodules of troilite were found on the interior free from any schreibersite. The Widmanstätian figures are readily developed, and are very large and regular.

Its specific gravity is 7·72. Its composition is—

Iron	89·12
Nickel	10·02
Cobalt	·26
Copper	·01
Phosphorus	·12

Some of the troilite was detached but not analyzed; its specific gravity is 4·73.

Rockingham County Meteoric Iron.

This meteoric iron was first brought to my notice, in 1870, by Prof. W. E. Kerr, the geologist of the State of North Carolina; but a short time afterward, seeing a notice of it by Dr. Genth in the Proceedings of the Academy of Sciences of Philadelphia, and as he proposed giving a further description of the same at some future time, I laid aside my notes concerning it; but having been frequently asked for particulars in relation to it from those possessing specimens, I have concluded to publish the notes made at the time it came into my possession.

This iron was discovered in Rockingham County, North Carolina, on a spot known as Smith's Mountain, two miles north of the town of Madison, about lat. 36° 20′, long. 79° 45′. It was found by Mr. Peters, from whom Prof. Kerr obtained it about the year 1863, and was lying on the surface of an old field which had been out of cultivation less than twenty years, and for that reason it is supposed it may have fallen within that time. It weighed originally about eleven pounds and was covered with a coating of rust. Its structure is highly crystalline, and when polished and either heated or acted on by nitric acid furnishes remarkably fine Widmanstätian figures, with delicate markings on the inside of the figures, which I designated sometime ago as Laphamite markings, having first observed them on the Wisconsin iron.

This iron contains narrow seams of schreibersite that penetrate the mass for several centimeters in different directions, some of them being two or three millimeters in thickness. In one part of the iron I discovered some solid chloride of that metal, enough to test its nature, and I detached a small fragment, that is now in the Museum of the Garden of Plants at Paris. It attracted moisture after being taken from a crevice in the iron, and became quite soft. This is the second time I have observed this solid chloride in meteoric iron. The nickeliferous iron, constituting the mass, exhibits the characteristics common to iron meteorites, viz: more or less diversity in the character of the iron in different parts, these varieties being so intimately associated that we possess no means of separating them. Dr. Genth considers it as composed of three different kinds of iron.

I selected a fragment perfectly free from any schreibersite visible to the eye; it gave a specific gravity of 7·78, and on analysis was found to contain—

Iron	90·88
Nickel	8·02
Cobalt	·50
Copper	·03
Phosphorus	·03

This will be seen to correspond to the analysis of Dr. Genth before referred to, which was as follows:

Iron	90·41	
Nickel (cobalt)	8·74	
Copper	0·11	
Iron	0·27	Phosphide insoluble in chlorhydric acid.
Nickel cobalt	0·33	
Phosphorus	0·14	

ART. XXV.—*Certain features of the Valleys or Water-courses of Southern Long Island;* by ELIAS LEWIS, Jr.

THAT portion of Long Island which lies southward of its central range of highlands, extending from near its western extremity to the Shinecock hills, is a plain, nearly level, traversed by numerous shallow valleys or water-courses. There are about thirty of these valleys, well defined, in a distance of fifty miles, between East New York and Riverhead, making one for a little less than two miles. In the lower end of most of them are flowing streams of singularly pure water, supplied by underdrainage of the region. The point where the springs break out in the valleys represents the surface of saturation in the soil. Above this point the valleys are dry excepting rarely when streams occur from surface-drainage during freshets, or from melting snow when the ground is frozen.

Few of these valleys are more than twenty feet in depth; their source is uniformly upon the high grounds, whence they extend southward to the bay. In some cases they may be traced nearly across the bay beneath its shallow waters to the verge of the ocean, affording evidence of a recent subsidence of the coast. A very marked peculiarity in their form is the steepness or abruptness of the banks upon their westerly sides, and the very gradual declivity of those upon their easterly sides. This feature is so obvious that it has long attracted the attention of travelers, and of others acquainted with this part of the island; and we know of no exceptions to it which cannot be explained by local conditions, such as may have arisen from confluence of streams or similar causes.

Another interesting feature of the valleys is their general direction. With some local exceptions their general trend or direction is a little west of south, and observation of them throughout their length renders it clear that this trend has arisen from some general cause acting during their erosion. The westerly or right banks have been eroded and worn away by the streams which formed the valleys, and now that the streams have ceased to erode them the steep banks remain.

The long declivities upon their easterly sides prove that the axis of the stream was originally several rods, in some cases from an eighth to a fourth of a mile eastward of where the axis, or deepest part of the valley now is. The phenomena we are considering cannot be explained by any merely local cause with which we are acquainted. The valleys are of post-glacial formation, and are in stratified gravels and sands distributed during the Champlain subsidence, and were probably formed as the coast gradually emerged from the water at the close of that period.

Features such as we have described have frequently been noticed in river valleys, but we are not aware of any instance where so large a number of short valleys, none of them more than ten miles long, present in so striking a manner the peculiarities mentioned.

That the cause is a general one seems probable. As suggested by Prof. Dana, who recently visited the island, the form and direction of the valleys in question may have arisen from the combination of motions to which Prof. Kerr of North Carolina attributes similar phenomena in the south-eastward flowing streams of that state. "The cause," Prof. Kerr observes, "is doubtless the rotation of the earth upon its axis co-acting with the river current." To a like combination of motions Prof. Maury, in 1855, referred some of the phenomena of ocean currents. The principle is the same that is exemplified in the circulation of ocean waters, in which, as a writer observes, "Any waters flowing from the polar regions (where the earth's motion is slow) toward the equator, would be thrown mainly against the west side of the oceans * * for they have no power to keep up with the earth's motion."

A similar result occurs with southward flowing streams over the land. For this reason the bank upon the west side of the stream is continually driven against it, in consequence of which the bank is abraded by the current, and worn away.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Rock-crystal Balance-beams, Thermometers, and graduated Circles.*—Stein, who, in 1874, proposed the manufacture of standard linear measures and weights in rock crystal, now goes farther and suggests the manufacture of balance-beams, graduated circles for telescopes, theodolites and quadrants, and even thermometers, of this material. With reference to weights, he states that the spherical form has been adopted in preference to the cylindrical, for many reasons, among others, because it is cheaper. For balance-beams, and scale-pans, the lightness of quartz, 2·65, is in its favor, aluminum being only 2·61; moreover its unalterability by chemical agents is complete. The construction presents no special practical difficulties. Graduated circles are cut from a quartz crystal perpendicular to the axis. For thermometers, a rod like that used for the linear unit can be bored lengthwise and the tube polished, an enlarged reservoir being made at the bottom for

the mercury, and the top closed with an air-tight stopper of the same material.—*Ber. Berl. Chem. Ges.*, ix, 1824, Jan. 1877.

G. F. B.

2. *Evolution of Hydrogen at both Electrodes in Electrolysis.*—ELSAESSER has made the curious observation that if a wire of magnesium be made the anode in a decomposition cell containing strongly diluted sulphuric acid, a wire of platinum being made the cathode, hydrogen gas is evolved at both electrodes, though at the anode only half as much gas appears as at the cathode; and that this ratio, though the total evolution of gas varies with the current-strength, remains constant. The same result happens when in place of the sulphuric acid, a moderately dilute solution of magnesium sulphate is used; only in this case, magnesium hydrate is deposited at both electrodes. Direct quantitative experiments showed that the quantity of magnesium dissolved at the anode corresponded exactly to the quantity of hydrogen set free there; the volume of hydrogen evolved at the cathode being the same as that set free in a voltameter in the same circuit. The author hence believes that the positivity of the magnesium is so increased by the current that it combines not only with the oxygen set free by this current, but also with additional oxygen, the hydrogen which was united to it, appearing in the free state. Why, however, this hydrogen should be exactly one half of that evolved at the cathode, is a question not yet capable of explanation.—*Ber. Berl. Chem. Ges.*, ix, 1818, January, 1877. G. F. B.

3. *Relation of the Molecular weights of Chemical substances to their Heat-absorbing power.*—AYMONNET has examined a number of simple liquids and also a number of solutions, with a view to measure their power of absorbing heat, in order to trace some connection between this property and their molecular weights. The heat rays were concentrated upon a slit half a millimeter wide, then passed through a tank containing the liquid to be examined, then through a lens and prism, producing a spectrum. A thermopile having an opening one millimeter wide was moved millimeter by millimeter along this spectrum, the deflection of the needle being constantly noted. From the data thus obtained the amount of heat transmitted is calculated; the difference between the results when the tank is full and empty being due clearly to the absorption of the liquid within it. The author concludes: 1st, that the molecular absorbing power appears to be constant: (A) for the elementary bodies when dissolved in the same medium; and (B) for elementary bodies which compose substances of analogous chemical constitution. Among other physical results, he has observed that when the temperature of a source of heat of known character is raised, the absorbing power of bodies submitted to the radiations from this source all diminish in the same ratio.—*Bull. Soc. Ch.*, II, xxvi, December, 1876. G. F. B.

4. *On the Existence of Solid Particles of Carbon in Luminous Flames.*—HEUMANN, in his fourth paper on the theory of luminous

flames, considers at length the question of the nature of the light-emitting material in luminous hydrocarbon flames, and concludes that it is really solid incandescent particles of carbon. The proofs he offers are: 1st, the increased luminosity which chlorine gives to weakly luminous or non-luminous flames, due to its well-known property of separating the carbon as such. 2d, a rod held in a flame is smoked only on the lower side, the side opposed to the gas stream; were the carbon there as vapor, as Frankland assumes, it would be condensed by a cooling action and so all around the rod. 3d, a body held in the flame is smoked even when it is in a state of ignition; this therefore cannot be condensation of a vapor. 4th, these particles can be actually seen in the flame when it is made to strike against a second flame or an ignited surface, these particles aggregating together to form visible masses. 5th, the luminous portion of a flame is not very transparent, no more so than the layer of smoke of the same thickness which rises above a flame fed with turpentine. And 6th, flames which unquestionably owe their luminosity to the presence of solid particles give a shadow with sunlight, precisely as do hydrocarbon flames; while luminous flames composed of ignited gases and vapors only, give no such shadow in sunlight.—*Liebig's Annalen*, clxxxiv, 206, Dec. 1876. G. F. B.

5. *Alcohol from the Leaves of the sugar-beet.*—PIERRE, assuming that the sugar found in the beet-root must be elaborated by the leaves, has examined these leaves for sugar. Owing, however, to the difficulty of preparing the sugar as such, he subjected the juice expressed from these leaves to fermentation, and from the alcohol obtained, estimated the quantity of sugar. The leaves employed were collected in November, and weighed 158 kilograms. They yielded 34 to 35 liters of juice, which after fermentation, gave 275 cubic centimeters of alcohol of 68 per cent. Calculating from these data, each hectare of land would furnish about 173 liters of absolute alcohol, as a minimum.—*C. R.*, lxxxiii, 1075, Dec. 1876. G. F. B.

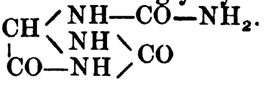
6. *On the Detection of ordinary Alcohol in Wood Spirit.*—BERTHELOT gives the following simple method of recognizing the presence of ethyl alcohol in wood-spirit. The suspected mixture is heated with twice its volume of concentrated sulphuric acid, and the gases evolved collected. If they consist solely of methyl ether, they will be entirely absorbed by water or by concentrated sulphuric acid; but if alcohol be present, ethylene will be formed which is insoluble in these menstrua under these conditions, while it is absorbed by bromine. So small a quantity as one or two per cent of alcohol may be recognized in this way. Acetone and other similar bodies present in wood-spirit, yield no ethylene.—*Ann. Chim. Phys.*, V, ix, 54, Sept. 1876. G. F. B.

7. *Synthesis of Allantoin.*—GRIMAUX, having observed that pyruvic acid in reacting upon urea generated a substance pyruvile $C_5H_8N_4O_3$, homologous with allantoin, inferred that its homologue, glyoxylic acid, by the same reaction would yield allantoin

itself. This he finds to be the fact. One part of glyoxylic acid and two parts of urea were heated to 100° for 8 or 10 hours, the mass was exhausted with four times its weight of boiling alcohol, and the residue insoluble in alcohol, was dissolved in 12 to 15 times its weight of boiling water. This on cooling deposited crystals, which after recrystallization appeared as brilliant hard lustrous prisms, giving on analysis the formula $C_4H_6N_4O_3$, and having all the properties of allantoin. The reaction is:

$$C_2H_2O_3+(CON_2H_4)_2=C_4H_6N_4O_3+(H_2O)_2.$$

The mode of its formation proves allantoin to be a glyoxylic diureide with the constitutional formula:



$$\begin{array}{l} CH\begin{cases} NH{-}CO{-}NH_2. \\ NH\diagdown \\ \end{cases} \!\!\! CO \\ |\quad \\ CO{-}NH\diagup \end{array}$$

—*Bull. Soc. Ch.*, II, xxvi, 482, Dec. 1876. G. F. B.

8. *Rhodein, a new test for Aniline.*—JACQUEMIN has proposed a new test for the presence of aniline, which is a modification of the hypochlorite test. A centigram of aniline in 500 c. c. of water, shows no reaction ordinarily with the hypochlorite of sodium. But if a few drops of a very dilute solution of ammonium sulphide (one drop to 30 c. c. of water) be added, a magnificent rose color is developed, due to a new body which the author calls rhodein. As 4 milligrams of aniline can be detected in a liter of water, the limit of delicacy in the reaction is $\frac{1}{250000}$.—*Ann. Chim. Phys.*, V, ix, 571, Dec. 1876. G. F. B.

9. *Sensitive Flames.*—Mr. R. H. RIDOUT has devised a form of burner by which great sensitiveness is attained at very low pressures, and thus the principal difficulty ordinarily experienced, of maintaining a high and constant pressure, is avoided. A glass or metallic tube, about five inches long, and five-eighths inch diameter, is closed at one end with a perforated cork, through which slides a piece of one-eighth tubing about six inches long. One end of this is either drawn out to a jet or closed in the blow-pipe flame to reduce its diameter to about one-sixteenth inch, and the other end is connected to a gas supply. The outer tube is held in a suitable support, and the inner tube is pushed through the cork till it nearly reaches the mouth of the outer one, and a light is then applied. It now gives a long steady flame which is easily rendered sensitive by lowering the inner tube. Several effects are described which may be shown by it at any pressures above one-tenth inch of water.

A second arrangement is figured, in which two parallel vertical tubes are connected by a horizontal tube in which a drop of water is placed as an index. A very slight excess of pressure is shown by the motion of the drop to one side or the other. Allowing gas to flow through both tubes and lighting either jet the water will move toward the other, showing that the effect of the combustion is to obstruct the flow. Similarly it may be shown that a sensitive jet produces a greater resistance when its length is shortened by a noise or musical note. This effect may also be shown whether the jet is lighted or not.—*Nature*, xv, 119. E. C. P.

10. *Theory of Luminous Flames.*—Dr. **Karl Hinmann** has published an elaborate discussion on this subject, in which he concludes that the theory of Davy must be altered, but need not be replaced by a new hypothesis. From a discussion of the work of previous observers, and a variety of experiments on the diminution and restoration of luminosity in hydrocarbon flames, and on the distance between flame and burner, he arrives at the following conclusions.

(1.) The fact that a gas-flame does not rest upon the burner, nor a candle-flame upon the wick, as also the fact that a flame never directly touches a cold body held within it, is to be explained by the cooling action exercised upon the gas by its surroundings. The combustible gases are cooled throughout a definite space below their ignition-temperature; the flame is therefore extinguished. This conclusion is opposed to that of Glochmann.

(2.) The very considerable distance noticed between the burner and the flame of a gas issuing under high pressure, or mixed with a large column of an indifferent gas, cannot be accounted for on the grounds put forward by Benevides. The production of such a distance is much rather to be traced to the cooling action of the stream of gas and of the outer air, and perhaps more especially to the fact that the velocity of the stream of gas in the neighborhood of the burner is greater than the velocity of propagation of ignition within the gas.

(3.) In order that other circumstances conditioning the effect may be removed, the velocity of propagation of ignition must be equal to that of the gas-stream at the point, situated some distance from the burner, where the flame begins.

Determination of the velocity of ignition should be made under these conditions for different gases, and since this magnitude is a function of the difference between ignition and combustion temperatures, conclusions may be drawn from such experiments regarding the relations existing between these points.

(4.) The velocity of propagation of ignition may be easily determined for solid and liquid combustible bodies; and the numbers so obtained may be regarded as comparative quantitative expressions for the liability to ignition of these substances.—*Ann. der Chemie*, clxxxi, II, 129, clxxxii, 1; *Phil. Mag.*, iii, 1. E. C. P.

11. *Influence of Pressure on Combustion.*—M. **Wartha** has observed the burning of six stearine candles in free air, and in an iron case under a pressure of 1·95 atmospheres. They burned under this pressure with a flame of 9 to 12 cm. long, and gave much smoke; their luminous power diminished, while the flame assumed a yellowish-red color. The decrease of weight after one hour of burning was found to be less than in burning in free air. This last result is opposed to the observations of Frankland, who has affirmed that the consumption of the burning material of a candle, or the like, is not perceptibly dependent on the pressure of the medium in which the combustion occurs. It is supposed that the difference of pressure in Frankland's experiments (on

Mont Blanc and at Chamounу) was not sufficiently great to give a distinct difference in consumption of the burning matter. M. Wartha further put a candle to burn under an air-pump receiver, with special apertures, and, with increasing rarefaction, the flame was seen to enlarge, and its luminous power to diminish. At a pressure of 90 mm., the greatest rarefaction produced, the luminous power was quite gone, and the flame, which now assumed three-fold size, appeared to consist of three parts, an inner bluish-green cone with a violet sheath, and a weakly violet mantle. The diminution of the luminous power in this case M. Wartha explains by the fact that under less pressure less of the products of combustion are separated in the form of soot.—*Nature*, xv, 167. E. C. P.

12. *Large Induction-Coil.*—Mr. Wm. Spottiswoode has had the largest induction-coil yet made, constructed for him by Mr. Apps. This coil, which is capable of giving sparks 42 inches long, is constructed as follows: It has two primaries, one used for long sparks which has a core consisting of a bundle of iron wires ·032 in. thick, forming a solid cylinder 44 in. long, and 3·5625 in. in diameter. Its weight is 67 lbs. The copper wire of this primary is 660 yards long, ·096 in. in diameter, has a conductivity of ·93 and a total resistance of 2·3 ohms. It contains 1,344 turns wound singly in six layers, has a total length of 42 in. with an internal diameter of 3·75 in. and an external diameter of 4·75 in. The other primary, which is intended to be used with batteries of less resistance for short, thick sparks, or for spectroscopes, is heavier than the other, the core weighing 92 lbs. and the wire 84 lbs. The latter may be so connected as to be equivalent to a wire of double or six times the cross-section of a single wire. The secondary coil consists of 280 miles of wire arranged in 341,850 turns. It forms a cylinder 37·5 in. in length, 9·5 internal and 20 inches external diameter. The total resistance is 110,200 ohms. It is wound in four sections, the diameter of the wire in the two central sections being ·0095 and in the outer ·0115 and ·0110. The increased section of the extremities is to allow for the accumulated charge that portion of the wire has to carry. The condenser required proved to be smaller than was anticipated. The size commonly employed with a 10-inch coil gave the best results. It consists of 126 sheets of tin-foil 18×8·25 in., separated by two thicknesses of varnished paper, ·0055 thick. With 5 quart cells of Grove, a spark of 28 inches was obtained, with 10, one of 35 inches, with 30 one of 37·5, and later, one, of 42 inches. As these sparks were obtained without difficulty, it appears not improbable that, if the insulation of the ends of the secondary wire be carried further than at present, a still longer spark might be obtained. The insulation is such that 70 cells have been used without injury. With the 28-inch spark a block of flint-glass three inches in thickness has been pierced. When used for vacuum tubes this coil gives illumination of extreme brilliancy

and very long duration; with 20 to 30 cells and a slow working mercury break, giving, say 80 sparks per minute, the striæ last long enough for their forward and backward motion to be perceived directly by the unassisted eye. The appearance of the striæ when viewed in a revolving mirror was unprecedentedly vivid, and this even when only two or three cells were employed.—*Phil. Mag.*, iii, 30. E. C. P.

13. *Lectures on some Recent Advances in Physical Science, with a Special Lecture on Force;* by P. G. Tait, M.A. Second edition, revised. London, 1876. (Macmillan & Co.)—The lectures of Professor Tait, as is stated in the preface to the first edition, were delivered in the spring of 1874. They are printed in the same form in which they were given in the lecture-room, with only occasional changes; the somewhat familiar way in which the principles are presented, however, is by no means a defect in the book, but on the contrary makes it all the more interesting and readable. Of the thirteen lectures in the first edition about one-half are on the subject of the Conservation and Transformation of Energy. The clear and systematic way in which Professor Tait has developed this most important subject makes the book an invaluable one for all who would become familiar with the principles upon which modern Physical Science is based. Not the least interesting of the lectures devoted to this matter is the one in which the early history of Energy is discussed, from the laws of Newton to the experiments of Joule and Colding. The remaining six lectures are devoted to: Radiation and Absorption, the Spectrum Analysis, the Conduction of Heat, and the Structure of Matter. These subjects are treated in the same clear, logical way which characterizes the discussion of the principle of Energy. A lecture on the subject of Force has been added to the second edition of the work; it was originally delivered in September, 1876, before the British Association.

II. GEOLOGY AND MINERALOGY.

1. *Grand'eury on the Carboniferous Flora.**—This remarkable memoir, though entitled the Carboniferous Flora of the Department of the Loire and of Central France, discusses the comparative distribution of the coal plants of all parts of the world, and the botanical relations of all the genera of the Coal period, so that it is quite as much a general as a local work; and it is in truth one of the most important contributions made for a long time to our knowledge of the Paleozoic Flora. One of its distinguishing characteristics is the attention given by the author to the study of plants *in situ*, and to the relation of their parts to each other, as ascertained in the beds in which they lie. The description of coal plants from mere fragments of leaves or stems, or even from

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* Flore Carbonifère du Departement de la Loire et du Centre de la France, par F. Cyrille Grand'eury, (Mem. Acad. Sci. France.)

detached fruits, must always be unsatisfactory, and yet this is all that has been possible to many eminent and laborious workers in this field. We need however much more than this. The paleobotanist must dig for himself, and spare no labor to trace up any plant to its leaves and fructification on the one hand, and to its roots on the other. For work of this kind, M. Grand'eury seems to have enjoyed great facilities, more especially in the sections at St. Etienne, which rival those of the South Joggins and North Sydney in Nova Scotia in their exposure of plants *in situ*, while they seem even to excel them in the preservation of minute structure. The result is that M. Grand'eury affirms with confidence many correlations of parts and structures, heretofore attested on the evidence of actual observation in the Nova Scotia sections, but which have been persistently denied by some European botanists, because not in harmony with their preconceived views.

In the strictly botanical part of the work, which extends to 348 quarto pages, with an atlas of thirty-seven plates, M. Grand'eury passes in review all the leading genera of coal plants, and more especially those which constituted the forest trees of the period. We can notice only a few of the more important points on which he touches.

Beginning with the order of *Calamariæ*, which he recognizes as belonging to the vascular Cryptogams and near to the modern *Equisetaceæ*, he admits as true genera *Calamites*, *Asterophyllites*, *Annularia*, *Equisetites* and *Sphenophyllum*. This is in accordance with the views always held by our American paleo-botanists, but contrary to the hasty statements which have sometimes been made elsewhere, that the leaves known as *Asterophyllites*, *Sphenophyllum*, etc., were those of *Calamites*, and that *Calamites* them selves are but internal casts of *Calamodendra*. On these points M. Grand'eury brings many new facts to show diversities in structure and fructification between these plants. He recognizes, however, some *Volkmanniæ*, as being fruits of *Asterophyllites*, and *Pinnulariæ* as roots of *Annularia*. The phenomena of erect stems of *Calamites* retaining their roots and other appendages, and the structure of these stems, have forced him to the same conclusion always maintained by the writer of this article, that while, as Williamson has shown in his admirable memoirs, there are calamite-like bodies which are internal casts of stems of *Calamodendra*, there are true *Calamites* of quite distinct nature. Of the rhizomes of some Calamites, their branching at the base and sides, so as to form stools or clumps, and their following up the increase of the sediment around them, by sending out branches at various heights, he has numerous examples. He denies the Calamites true leaves, and thinks that their verticillate branches and branchlets, which are sometimes though rarely preserved in Nova Scotia, were either unusual or very deciduous.

The discussion of the Ferns is full of interesting matter; but cannot be entered into here, except to state that he sides with the writer in regarding *Megaphyton* as a tree-fern with leaves in two series, and aerial roots (as restored in Acadian Geology, p. 448), and recognizes one of his French species as identical with *M. McLeayi* of Lesquereux. In the order Lycopodiaceæ he makes the *Lepidodendreæ* a separate family, including the genera *Lepidodendron* and *Lepidophloyos*. The latter is an old and natural genus of Sternberg, very much ignored in England, but which has been recognized and used by paleo-botanists in this country. Under the name *Pseudosigillaria*, he includes some stems referred by authors to *Sigillaria*, but which, on grounds connected with the nature and arrangement of the leaf-scars, he very properly associates with the *Lepidodendra*. There can be no doubt that many cases of this kind exist; though it may be doubted whether the founding of a genus for them is the best mode of disposing of such doubtful specimens. *Knorria* and *Halonia* are recognized as imperfectly preserved or aberrant *Lepidodendreæ*.

Perhaps the most remarkable part of this memoir is the great development which it gives to the group of Gymnosperms, which, as represented in the Coal formation, he divides into the orders of the *Sigillariaceæ*, the *Cordaiaceæ* and the *Calamodendraceæ* with the uncertain group of *Noeggerathiæ* As to the Sigillaria family, he merely ventures to divide the great genus *Sigillaria* into provisional sub-genera in the same manner in which this has been done by others; but he recognizes *Syringodendron* as a separate genus. He thinks this last must have had very minute leaves, and he refers to it, as its roots, certain Stigmarioid organs which he terms *Stigmariopsis*, and which differ in some particulars from the true Stigmaria roots of the *Sigillariæ*. As to the true *Sigillariæ*, he holds with Brongniart, and with Newberry and the writer in America, that they are Gymnospermous, or perhaps, more precisely, that the true *Sigillariæ* are of this rank, but that some of the species confounded with these by their similarity of external markings, may be allied to the *Lepidodendra*. He does not seem to have met with any specimens that show the advanced structures, approaching to those of the Cycads,* found in some Nova Scotian specimens, but he considers the structure of the stem exogenous, and the resemblances which it presents to *Lepidodendron* as merely depending on adaptation to a similar habitat. He has not found the fruit of Sigillaria in place, but believes that he has discovered indications of seeds borne on the bases of leaves, and he is also inclined to accept the circumstantial evidence adduced by Dr. Newberry and the writer, that the *Trigonocarpa* and similar fruits may have belonged to some species of *Sigillaria*.

The elevation of the genus *Cordaites*, hitherto very imperfectly known, to the rank of the type of an order is a feature in this memoir. In some parts of America the leaves of these plants occur in excessive abundance, beds of shale being filled with them and layers of coal apparently composed of their remains; and they range all the way from the Middle Devonian to the Permo-Carboniferous. But they are invariably found as detached leaves, and their broad thin bases give the idea of an attachment to merely herbaceous stems. These stems have not, so far as I am aware, been found in America with their structure preserved; and Corda, who alone had figured this stem from European specimens, represents it as having a slender axis of scalariform vessels resembling that of a Lycopodiaceus plant, and indeed not more developed than that of the *Psilophyton* of the Lower Devonian. M. Grand'eury reverses all this. He adduces facts which it would be impossible here even to summarize, to show that some at least of these plants were of arboreal dimensions and that they had woody stems similar to those of Conifers. He even attributes to them the wood hitherto known as *Dadoxylon*, though in this we can scarcely agree with him. They are divisible into several generic forms, as *Cordaites*, *Dory-cordaites*, *Eu-cordaites*, and *Poa-cordaites*, which it is however admitted may be very distinct from each other in structure and affinities. Their fruits were the *Cardiocarpa* and other kinds of *Carpolites*, and when borne on the plant, they constituted spikes which have been known as *Antholithes*. The material illustrative of this new order at Grand'eury's disposal has been very extensive, and his conclusions deserve careful study and attention, though one can hardly help suspecting that he has united to the ordinary *Cordaites* plants of much higher affinities.

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* Incorrectly said to resemble Conifers, which is a misapprehension, arising perhaps from the imperfect way in which they have been figured.

The *Calamodendra*, whose structure was first made out by Cotta, and which have lately been so well illustrated by Williamson, are here elevated into a family, which includes the two genera *Arthropitus* and *Calamodendron*, agreeing in having an internal jointed medullary cavity resembling a Calamite, but differing in the structure of their wood; that of *Calamodendron* consisting of alternate radiating plates of fibers without definite order and others in radiating series. The leaves of these plants have probably been confounded with those of *Asterophyllites*, and are narrow, rigid and verticillate. Williamson has shown that *Calamostachys Binneyana* and a species of *Volkmannia* have structures similar to those of *Calamodendron* and *Arthropitus*. Grand'eury believes that these may be male strobiles with pollen, and that the true fruits may be of the kinds known as *Polypterocarpus* and *Stephanospermum*.

The concluding plates of the memoir give a series of restorations of the principal arborescent plants of the Coal formation, which are all highly suggestive, and many of them fully warranted by the facts stated in the memoir. The part of the memoir devoted to the geological relations of the plants described might well merit a separate notice. It treats of the best manner of subdividing the Carboniferous System; of the characteristic plants of each stage of the system, not only in France but elsewhere; of the plants which have principally contributed to the formation of coal; and of the relations of these plants to the thickness, quantity and age of the coal-seams. There is of course also a large amount of local detail relating to the French coal-fields.

On the whole, this memoir should be welcomed by all paleontologists. It is undoubtedly most accurate and trustworthy as to the affinities of the coal plants which the author has been able to study in their various parts and organs; and in respect to all, it is most suggestive, and cannot fail to lead to clearer views of the whole subject. One conclusion which must strike every one, and on which the writer of this notice has long insisted, is that the arboreal vegetation of the Coal period must have been much more varied than has been usually supposed; and that while we have no doubt been instituting many unnecessary species for mere fragments, we have on the other hand been forcing into unnatural union very diverse forms, by trusting to merely external characters. J. W. DAWSON.

2. *Memoirs of the Geological Survey of Kentucky*, N. S. SHALER, Director. Vol. I, 334 pp. 4to. 1876.—This first volume of the publications of the Geological Survey of Kentucky, contains four Memoirs.

The first is on the Antiquity of the Caverns and Cavern life of the Ohio valley, and is by Prof. SHALER. We learn from it that in the Mississippi valley, while the limestone of the Cincinnati group contains a few true caverns, far the larger part, and the largest, occur in the Subcarboniferous limestone. In Kentucky, this limestone has an average thickness of 150 feet and the caverns are exceedingly numerous; the author states that the length of the underground channels in this rock accessible to water is many tens of thousands of miles; and he thinks it no overstatement to say that there are at least 100,000 miles of open caverns. Owing to these channels, the traveler may journey for fifty miles over many parts of this limestone region in the wet season and meet with no running water. In the history of the caverns a firm bed of limestone has often held the streams for a long period, and thus a tier of caverns has been made; and then, this bed becoming worn through, the waters have descended and commenced work at a lower level, and so successive tiers have resulted. Prof. Shaler observes that the most surprising feature in the architecture of these caverns is the existence of great "domes" or wells which often rise in a single sweep from the lowermost to the uppermost level of the caves; and which are due to a fall in the course of an underground stream that originated in the early history of the cavern. Often a "sink-hole" opening to the light begins the vertical channel. Thus vertical channels, and lofty domes, tiers of great caverns along successive levels communicating with one another by the channels and domes, with streams varying from still pools to high waterfalls and using pebbles for abrasion in the lower portions, are the principal elements of these caverns. The massiveness of the limestone favored the formation of great caverns, and this massiveness Prof. Shaler attributes to its having been formed chiefly of crinoidal remains. The great profusion of crinoids and the enormous area of the Carboniferous indicates, he remarks, a wide, warm, and comparatively shallow (the Molluscan remains being quite large) sea, its waters richly charged with carbonate of lime.

Prof. Shaler discusses at length the age of the caverns and states as his conclusion that probably "while some caverns may have existed in the Mississippi valley long before the Tertiary period, their great development, with the consequent chances of organic life finding its way into cavern conditions, is a very recent event."

The second memoir is Prof. J. A. Allen's able paper on the American Bisons, living and extinct, already noticed on page 75 of this volume.

The third is by Prof. Shaler and is the first of a series on the fossil Brachiopods of the Ohio valley. The author, in this paper, takes up the very important question of amount of variation in some of the more variable species, and presents tables of measurements, in addition to detailed remarks on the different characters and the distribution of the species. For example, under *Orthis occidentalis*, measurements of 40 specimens from a number of localities are given, including dimensions as to length and width of shell, length of hinge-line and of muscular impression, width and height of foramen, and other points. The memoir is therefore an important contribution to the subject of the variation of species. These variations are wonderfully great in many cases. Thus in the above species the proportion in length to width varies from 1 : 1·05 to 1 : 1·50. This article is illustrated by seven plates, prepared, like other plates of the volume, by the autotype process, which avoids all error of drawing; and it is stated by the author that he first bedded the specimens in white sand, thereby doing away with the shadows which make one of the difficulties in properly taking a photograph for this process.

The fourth memoir, by Mr. Lucian Carr and Prof. Shaler, treats of the prehistoric remains of Kentucky. It contains a very judicious discussion of the value of the remains in North America as a measure of time, together with other interesting descriptive and historical matter, and notes on the source of the material of the implements, and on their distribution in Kentucky. It is illustrated by seven plates, containing autotype reproductions of arrow heads, pipes and other articles.

This last paper is to be continued in the second volume of Memoirs, which volume will contain also, as announced in the Preface, the following additional memoirs: on the Fossil Corals of Kentucky, on the Fossil Brachiopods of the Ohio Valley, and on the Dynamic Geology of Kentucky, by Prof. SHALER; on the Cavern Animals of Kentucky, by A. S. PACKARD, F. A. SANBORN and others; on the Cavern-dwelling Races of Kentucky, by F. W. PUTNAM; a history of the Investigation of Cavern Animals, by Dr. H. A. HAGEN.

The Memoirs published by the Survey on purely scientific subjects, like those mentioned above, will make a series of publications distinct from chapters on economical matters. The Preface states that the Memoirs may be purchased separately or in volumes at the office of the Survey in Frankfort, Kentucky.

3. *Report of a Reconnaisance from Carroll, Montana Territory, on the Upper Missouri to the Yellowstone National Park, and return, made in the summer of* 1875; by Wm. Ludlow, Captain of Engineers, Brevet Lieut. Colonel U. S. Army, Chief Engineer Department of Dakota. Being Appendix NN of the Annual Report of the Chief of Engineers for 1876. 142 pp. 8vo. 1876.—The report of Colonel Ludlow gives excellent descriptions of the topographical features of Montana and the region beyond traversed by his expedition, with notes also on routes, cañons, the geysers of the Yellowstone Park, and many other subjects of interest.

The volume also contains a Zoological Report by George Bird Grinnell, which is an annotated Catalogue of Mammals and Birds, and a Geological Report by Messrs. Edward S. Dana and G. B. Grinnell. The subjects treated of in the last-mentioned report are the alluvial deposits of the Upper Missouri; the Cretaceous at Carroll and beyond; the Judith Mountains, where were beds of Cretaceous age, and the trachytic "Cone Butte," a conical hill, about 3,400 feet in elevation above the level of the Missouri River, the average height of the Judith Mountains; the vicinity of the Moccasin Mountains, whose appearance "indicated that, like the Judith Mountains, they are largely trachytic;" the vicinity of Camp Lewis, where the beds were reddish clays and shale, and probably Cretaceous; the west end of the Judith Mountains, in which limestone bluffs containing Carboniferous fossils were visited; the region beyond to Camp Baker, passing over Carboniferous limestone in Musselshell Cañon, dipping 50° to 60° to the south of west, which, through an overturn, was overlaid by Lower Silurian (Primordial?) strata, and finding the central portion of the Little Belt Mountains to consist of trachyte; Camp Baker and beyond toward Fort Ellis, where occurred, besides the prevailing Miocene beds (containing remains of *Oreodon*, *Rhinoceros*, etc.), a limestone of Primordial age, affording an *Obolella*, and new species of Trilobites of the genera *Arionellus* and *Crepicephalus*, along with red shales and quartzyte of the same age; the Bridger Mountains, having Cretaceous beds on the east, next Jurassic (red bands, with Jurassic fossils), and then Carboniferous limestone at the summit, with older rocks on the west, having in places a reversed dip; the geysers of the Yellowstone Park.

The occurrence of a Miocene Lake Basin in the vicinity of Camp Baker is the subject of an article by the authors in vol. xi of this Journal (p. 126). The Cretaceous formation underlaid the prairie along nearly all the route followed. The most prevailing member was No. 4, of Meek and Hayden, or the Fort Pierre Clays. But besides this, No. 5, or the Fox Hills Group, was observed at several points, and No. 6, or the Fort Union Group, at the mouth of the Judith River, overlying No. 5, where the bones of a *Hadrosaurus* were obtained.

The new species of fossils collected are described by R. P. Whitfield, and figured on two plates. The trilobites above referred to are named by him *Crepicephalus* (*Loganellus*) *Montanensis* and *Arionellus tripunctatus.* He also describes the following new species of Jurassic age from the Bridger Mountains: *Gryphæa plano-convexa*, *Gervillia sparsalirata*, *Myalina* (*Gervillia*) *perplana;* also a new Pinna from the Carboniferous of the Musselshell, *P. Ludlovi.*

4. *The Yellowstone National Park and the Mountain regions of portions of Idaho, Nevada, Colorado and Utah.* Described by Prof. F. V. Hayden, Geologist-in-charge of the U. S. Government Exploring Expeditions to the Yellowstone Valley, and of the U. S. Geological and Geographical Survey of the Territories. Illustrated by chromo-lithographic reproductions of Water-color sketches by Thomas Moran, Artist to the Expedition of 1871. Fifteen plates in large folio, with text by Prof. Hayden. Boston. 1876. (L. Prang & Co.)—This volume of colored sketches, illustrating some of the most striking points in Rocky Mountain scenery, is magnificent in scale and beautiful in execution. Mr. Moran is well known for his fine landscapes; and it is fortunate that such a painter has been over the wonderful Yellowstone region with his pencil. The colors of the landscapes will be thought too brilliant by those who have not visited the region, and perhaps in one or two cases the artist has allowed his feelings in that exhilarating atmosphere to influence in some degree his brush. But, in other cases, that for example of the scenery along the Cañon of the Yellowstone, as we understand from one who has visited the region, the colors even fall short of the reality. Speaking of the variety and richness of tints over the rocks of that region and others adjoining, Colonel Ludlow says (in the Report noticed on page 228): "Throughout this elevated region [the Judith Basin], and more especially beyond in the Yellowstone Park, we had daily occasion to observe the marked depth and clearness of the coloring, owing, I presume, to the utter purity of the atmosphere. The colors of objects comparatively near by seemed to possess an unsurpassed richness and reality; and even on distant mountains, seventy-five or eighty miles away, while the tints were necessarily blended and their details lost, they exhibited a wonderful transparency and distinctness, undimmed by the haze and vagueness which usually obscure such objects." He thus confirms the descriptions which Dr. Hayden and others have given of the strange variety and beauty of coloring that characterize the rock-scenery of that region, and not of that alone in the Rocky Mountains. The subjects of the landscapes are the following: (1) Hot Springs of Gardiner's River, Yellowstone National Park; (2) The Great Blue Spring of the Lower Geyser Basin, Yellowstone National Park; (3) The Castle Geyser, Upper Geyser Basin; (4) Lower Yellowstone Range, seen from the Yellow-

stone Park; (5) Yellowstone Lake; (6) Tower Falls and Sulphur Mountain, Yellowstone Park; (7) Head of Yellowstone River; (8) The Grand Cañon of the Yellowstone; (9) The Towers of Tower Falls; (10) The Mountain of the Holy Cross, Colorado; (11) The Mosquito Trail, Rocky Mountains of Colorado; (12) Summit of the Sierra Nevada; (13) Great Falls of Snake River, Idaho; (14) Valley of Babbling Waters, Southern Utah; (15) The Great Salt Lake of Utah. As specimens of chromo-lithography and of artistic effect, the plates are of unusual excellence.

Prof. Hayden, having become familiar with the region of the Park through his two years of exploration there, and also with the other parts of the mountains in the course of his repeated expeditions, was well fitted to prepare the text for this book of Rocky Mountain landscapes.

5. *Report on the Geological Survey of Alabama*, for 1876; by EUGENE A. SMITH, State Geologist. 100 pp. 8vo. Montgomery, Alabama.—The work during 1876 was confined to the valley known as Roup's Valley and Jones's Valley. The valley occupies the summit of an anticlinal in the southwestern end of the Appalachian region, and has the coal basin of the Warrior on the west and that of the Cahaba on the east. The anticlinal has for the most part the beds sloping regularly outward on the two sides; but in the southwest extremity the fold has been lapped together and pushed over toward the northwest, reversing the dip, so that all the strata dip southeast.

The rocks described belong to the Lower and Upper Silurian, the Devonian and Carboniferous formations. The Upper Silurian is represented by beds of the Clinton group—the formation that in the north is noted for the presence of beds of red lenticular fossiliferous iron ore. In Alabama the same ore occurs in several beds. The strata in Tennessee constitute the Dyestone group of Professor Safford. Analyses of various iron ores and limestones are given in the Report.

6. *Annual Report of Progress and Results of the Wisconsin Geological Survey*, for the year 1876; by T. C. CHAMBERLIN, Chief Geologist. 40 pp. 8vo. Madison, Wisconsin, 1877.—This report contains a brief summary of the work done and results obtained during the year 1876. It states that "a collection of 20,000 or more fossils" has already been gathered, many of them new species, and that this part of the work is in the hands of R. S. Whitfield. Among the facts announced we learn that the copper-bearing series of Michigan, with its trap, extends nearly uninterruptedly across the northwestern part of Wisconsin; and in the bed of Nemakagon River, numerous masses of native copper have been found, associated with the trap, which apparently were not far removed from their native bed, indicating that it is a rich copper region.

Prof. Irving, one of the geologists of the Survey, reports, among other things, the existence of large quantities of kaolin in Wood and Jackson Counties.

7. *Report of the State Geologist of New Jersey*, Professor G. H. Cook, for 1876. 56 pp. 8vo.—This report states that the triangulation of the State by the Coast Survey has been continued through the year. A large part of the report is occupied with facts relating to the subject of water supply, especially for Newark and Jersey City, from the Passaic River water-shed. Analyses of the waters are given, and some effects on health from bad drainage and bad water. The average annual rain-fall deduced for all parts of New Jersey is thirty inches. Of this it is estimated, for the purpose of the calculations which follow, that forty per cent, or twelve inches, may be collected in streams and reservoirs, —which is not an over-estimate, since on the Croton water-shed it has been found that sixty per cent of the rain-fall runs off in the streams.

8. *Salt Region of Goderich, Canada.*—Prof. T. Sterry Hunt, in a recent article on this region, gives the following section and explanations.

BORING WITH DIAMOND DRILL MR. ATTRILL'S WELL, GODERICH.

	Feet.	Total.
Clay, gravel, and bowlders,	79	79
Dolomite, with a few thin limestone layers,	278	357
Limestone, with fossil corals, chert, and beds of dolomite,	273	630
Dolomite, with thin seams of gypsum,	246	876
Marls, red, green, and brown, with dolomite beds,	121	997
Rock salt; first bed.	31	1,028
Dolomite, with marls toward the base,	32	1,060
Rock salt: second bed,	25	1,085
Dolomite,	7	1,092
Rock salt; third bed,	35	1,127
Marl, with dolomite and layers of anhydrite,	80	1,207
Rock salt; fourth bed,	16	1,223
Marl and dolomite.	7	1,230
Rock salt; fifth bed,	13	1,243
Marls, soft, red and bluish, with beds of anhydrite,	136	1,379
Rock salt; sixth bed,	6	1,385
Marls, soft green and grayish, with dolomite and anhydrite,	132	1,517

From the above section it will be seen that from the top of the marls, which began at 876 feet, we have 641 feet of salt-bearing strata, including 126 feet of solid rock salt, and that the base of the series, that is to say the magnesian limestone of the Guelph formation which underlies it, was not reached. The rock salt is represented as forming six beds, but the second and third, and also the fourth and fifth, might each be looked upon as forming but a single bed, divided in two by a few feet of rock. The whole of this thickness of over six hundred feet of strata holds more or less salt, disseminated in small masses and in veins.

The salt of the different beds is not alike in purity. That of the upper one is somewhat discolored by an admixture of clay, and would need to be refined by solution; the same is true of the fourth and fifth beds, while the sixth is pure and white. The second and third, which may be considered together as one bed of sixty-seven feet of salt, including a layer of seven feet of rock, deserves more especial attention. This great mass carries at the top about one foot of colorless and transparent salt, followed by about fourteen feet of salt slightly discolored in parts by an admixture of a little clayey matter, and then by 10¾ feet of perfectly white and translucent salt of singular purity. Below this, after seven feet of rock, succeeds thirty feet additional of salt, nearly pure, but clouded in parts from the presence of a little clay.

In concluding, I may call attention to some new points in the geology of this salt deposit. By reference to the Geology of Canada (1863) and the geological map, it will be seen that Goderich is situated at the base of the Corniferous or Upper Helderberg limestone, which here rests directly upon a porous dolomite (magnesian limestone), supposed to represent the so-called water-lime beds at the summit of the Onondaga, as this salt-bearing formation has been named. The fossiliferous limestone strata known as the Lower Helderberg, which in New York are interposed between the salt formation and the Corniferous, have not, with the exception of the water-lime, been recognized in Western Ontario. The upper part of the Onondaga consists chiefly of dolomites, and the lower of marls, often with gypsum beds. Analyses of these rocks will be found in the Geology of Canada, (pages 625 and 807). Some of them yield excellent hydraulic cements. The whole thickness of this formation on the Niagara River is from 200 to 300 feet, but it increases greatly to the northwest, as shown by our section. These marls, which are mixtures of clay with magnesian carbonate of lime, are often very soft, and hence are sometimes called soapstone by the well-borers. It is hardly necessary to say that they have nothing in common with the true soapstone, or steatite, with which Mr. Gibson confounded them.

A fact of much interest to the geologist is the occurrence below nearly 300 feet of dolomite, of 273 feet of strata in which pure limestones prevail, accompanied toward the base with much white chert or hornstone. These limestones, for about 180 feet, or to a depth of 529 feet, abound in corals, chiefly species of *Favosites* like those of the Corniferous limestone. From these facts it would seem that the outer ocean, which at that time must have already contained the corals of the Corniferous period, invaded the area of the salt basin, and there formed the coralline limestones, after which it was shut out during the formation of the upper 278 feet of dolomite, when it again returned, depositing over the whole its covering of Corniferous limestone. Geologists will await with interest the result of a further study of the organic remains of this limestone, and as Mr. Attrill proposes to commence the work of sinking the shaft in the spring, an opportunity will soon be afforded. The task of opening a mine at this depth can scarcely be completed in less than two years, and may require a longer time.

9. *Glaciers in the Urals during the Glacial Era.*—It is reported by M. Poliakoff, that there are glacial striæ, scratched bowlders, and moraine deposits, on the east slope of the Urals, above the

level of the stratified sand and gravel. The glacial striæ have a southeast direction. A lower secondary ridge, the last crossed by the highway before Ekaterinburg, has many parallel ranges of immense bowlders.—*Nature*, Feb. 1.

10. *Trilobites.*—Mr. C. D. WALCOTT, of Trenton Falls, New York, a famous place for Trenton Trilobites, has succeeded in finding many specimens that illustrate directly, or by sections, the nature of some of the interior organs of the species. He has detected in many individuals axial appendages beneath the dorsal shell. In *Ceraurus pleurexanthemus* each segment of the thorax and pygidium and the three posterior of the head have a pair beneath the axial processes. Those of the thorax and pygidium appear to be short cylindrical supports for swimming appendages or rudimentary ambulatory organs; and those of the head present an obscurely jointed structure. In the same species there are "obliquely inclined bars beneath the pleural lobes, near the union with the free pleuræ," which he regards as connected with branchial appendages." In nine of his sections he has counted 43 such appendages. The bars appear to have had a fleshy or muscular support. The greatest number of bars seen in position belonging to one appendage is fourteen; it is rare to find them in position. Longitudinal sections at the union of the pleural lobes and free pleuræ show the branchial appendages as rows of dots, varying from square to oblong in shape. In *Calymene senaria* these appendages are essentially the same as in *Ceraurus*. Numerous central longitudinal sections of *Ceraurus* show the membrane covering the visceral cavity beneath the axial lobe. *Acidaspis Trentonensis* is closely like the *Ceraurus* in the structure of its ventral surface.

The ventral surface in *Asaphus platycephalus* appears to have been strengthened by arches, which supported the double row of appendages on each side of the central axis. These are the arches which were suspected to be legs by Billings.

These notes are from a brief paper by Mr. Walcott, from the 28th Report of the New York State Museum, printed in September last, in advance of its publication.

11. *Geology and Paleontology of the Argentine Republic.* II. Paleontological part; 2nd division, on the Rhetian plants and animal remains of the Provinces of La Rioja, San Juan, and Mendoza, by Dr. H. B. GEINITZ. 16 pp. 4to, with two plates.—The species here described by Dr. Geinitz are the fish, *Semionotus Mendozaensis* Gein., the Crustacean, *Estheria Mangaliensis* Jones, a species first described from Mangali of Nágpur in Central India; and among the plants there are the Ferns, *Thinnfeldia crassinervis* Gein., *Th.? tenuinervis* Gein., *Pachypteris Stelzneriana* Gein., *Otopteris Argentinica* Gein., *Hymenophyllites Mendozaensis* Gein., *Baiera tæniata* Braun, *Pecopteris tenuis* Schouw, a species described originally from I. Bornholm, and from Whitby, England, *Tæniopteris Mareyesiaca* Gein.; the Cycad, *Pterophyllum*

Oeynhausianum Göpp., a European species, and the Conifer, *Palissya Brauni* Endl. var. *minor*, Gein.

12. *Mémoire sur les Caractères Minéralogiques et Stratigraphiques des Roches dites Plutoniennes de la Belgique et de l'Ardenne Française*, par MM. Ch. De la Vallée Poussin et A. Renard. 264 pp. 4to, with nine plates, six of them containing colored figures of thin sections. A detailed account of the rocks referred to, based largely on the study of their sections. In the quartziferous dioryte of Quenast, the authors distinguished cubic crystals in the liquid filling minute cavities in the quartz, and proved the crystals to be chloride of sodium or common salt.

13. *Note on the new localities of the Columbic acid minerals, and two new Columbates;* by J. Lawrence Smith.—The locality near Marion, North Carolina, is now well known, as furnishing large and fine specimens of Samarskite. It was doubted by some mineralogists whether or not it was true Samarskite. I have been able by chemical analysis to establish beyond all doubt that it is a very fine type of this rare mineral (the cause of the doubt I will refer to another time), confirming Mr. E. S. Dana's conclusion, based on its crystallographic character. In studying the mineral, I found associated with it three other columbates—one of them already known, viz., Euxenite, and two new ones. One is in the form of a very characteristic mamillary concretion, and contains sixteen per cent of water. The other is found massive, and also in regular octahedrons, of which a few have been found; it resembles somewhat pyrochlore, but differs from it both by its chemical and physical characteristics, its specific gravity being 4·85. The latter mineral I saw about eight months ago, in the hands of Mr. J. Price Ralston, and then supposed it was new. He had sent a specimen to Mr. E. S. Dana, who gives some of its characters in connection with his crystallograpic description of Samarskite, and refers it with a query to microlite. Since then Mr. Ralston has kindly sent me his crystals, and I have now made out its nature thoroughly. The analysis of it will appear in a forthcoming paper on the American columbates.

In addition to the above, I have discovered embedded in the beautiful crystals of Amazon stone, from Colorado, very small, perfect crystals of columbite.

14. *Bulletin of the Bussey Institution, Jamaica Plain, Boston, Mass.* Vol. ii, part I. 80 pp. 8vo. 1877.—Among the papers in this valuable bulletin there are the following by Prof. F. H. Storer: on the amounts of potash and phosphoric acid in several kinds of rocks; on the agricultural value of spent dye-woods and tan; on the composition of buck-wheat straw; on the fertilizing power of roasted leather; notes of experiments in which buckwheat plants were watered with solutions of peat in alkalies.

From the first, treating of the presence of *Phosphates and Potash in Rocks*, we learn that seven granites, all from eastern Massachusetts, excepting one from the base of Monadnock, New Hampshire, afforded 2·587 to 7·434 p. c. of potash, and 0·058 to 1·191 of phosphoric acid.

	P_2O_5	K_2O
ur syenites, eastern Massachusetts	1·407–5·241	0·042–0·066
ca schist from Dracut	4·356	0·287
npact blue slate from Somerville	3·875–3·913	0·085
" "	1·294	0·098
rap" from "Milk Row Quarry"	0·303	0·444
" West Dedham	1·007	0·194
artz rock, with streaks of feldspar, West Dedham	5·035	0·053
ach sand, Essex, Mass.	2·384	0·051
ne sand, Provincetown, Mass.	0·613	0·050
nd from bed near the Bussey Institution	0·891	0·035
ite Berkshire sand used for glass making	0·448–0·630	0–0·021

15. *Heights on Long Island.*—The following facts are con- buted in a letter to Professor James D. Dana, from Mr. E. wis, Jr., of Brooklyn, giving the elevation and position of some the principal hills upon Long Island. The range of hills which tends with some interruptions through a considerable portion of ng Island, varies from 150 to 384 feet above tide, and is of great ological interest. They constitute a prominent feature of the eat terminal moraine of the ice sheet upon this part of the ocean rder, and afford, as I have elsewhere shown, data by which cent oscillations of the coast may be determined.[*] Indeed, it is the presence and position of beds of modified drift upon these ls, and along their slopes, that the extent of subsidence since e bowlder drift was deposited can be made out.

The heights given are in part from the manuscript records of . Hassler, kindly furnished by the Coast Survey office. Others e from measurements made by the writer and others. In the mediate vicinity of some of the hills whose heights are given e others, nearly as high, forming groups, as West Hills and Dix lls groups in Suffolk County. With the heights is given the stance of each locality from the City Hall in New York, as laid wn on the Map of Long Island. Beginning at the extreme stern end of the island we have:

	Elevation.	Distance.
Montauk Point,	85 feet.[†]	113 miles.
Fort Pond Hill,	194 " [†]	108 "
Neapeague "	135 " [†]	102 "
Amagansett "	161 " [†]	98 "
Shinecock "	140 " [†]	80 "
Osborn's " (near Riverhead),	293 " [†]	68 "
Ruland's " (South of Coram),	340 " [†]	55 "
West Hills, (High Hill Field, known as Jane's Hill,[1]	354½ "	31 "
Layton's Hill, (Wheatly),[2]	380 "	22 "
Westbury Hill,[4]	260 "	22 "
Hempstead Harbor Hill,[3]	384 "	20 "
John M. Clark's Hill, (Manhasset),[4]	326 "	16 "
Smith's Hill, " [4]	332 "	16 "
Prospect Hill, (Brooklyn),	194 " [†]	

Height by Coast Survey 383 feet. I found it by aneroid to be scarcely more n 355 feet. A. J. Spooner, Esq., in his memoir of the Hon. Silas Wood, late of ntington, says, "He (Mr. Wood), had the elevation of Oakley's High Hill Field en in October, 1825, by Mr. Abel Ketcham, an accurate surveyor, who deter- ed the height to be 354½ feet above the water level of the Sound." The survey he states was recorded in the Town Records of Huntington. It is possible that in transcribing, 353 feet may have been mistaken for 383 feet.

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[*] This Journal for March, 1877. Popular Science Monthly, Feb., 1877.

[†] From U. S. Coast Survey.

[2] The heights of this great mound of unmodified drift is not satisfactorily determined. The height given is nearly correct.

[3] Measured from half-tide level by Hon. Stephen Tabor, of Roslyn.

[4] Heights determined by George B. Brainerd, Esq., Engineer in the Brooklyn Water Department, and by the writer.

From the hills mentioned, and from others of the range, extensive views may be had, and the contour of the island throughout its entire breadth studied to great advantage. A striking feature observed is the vast, nearly level plain which extends from the foot of the hills southward to the Great South Bay. At a distance of from one to two miles from the foot of the hills the following elevations above tide were determined by early surveys, for the Long Island Railroad. I quote from Prime's History as follows:

1.	Bedford, (in the city of Brooklyn),	73	feet.
2.	Jamaica,	40	"
3.	Mineola,	103	"
4.	Hicksville,	142	"
5.	Farmingdale,	63	"
6.	Suffolk Station,	90	"
7.	Medford,	82	"
8.	Riverhead,	32	"
9.	Southold,	40	"

The average elevation of the "Plains," so-called, along the line of the railroad, is therefore about 70 feet. Northward of the hills, extending to the Sound, the surface is uneven, and no general topographical survey of it has been made. We have, however, the elevations at several points. Some of these exceed 200 feet, and an estimate of the general elevation of the surface formerly made, of from 130 to 150 feet, is not far from correct.

III. Botany and Zoology.

1. *Dextrorse and Sinistrorse:* Which is right and which is left, as applied to twining, overlapping in flower-buds, and course of the spiral in phyllotaxis? There are two opposite ways of regarding it; according to one a hop-vine turns to the left, according to the other, to the right; and authorities and usage are divided. Uniformity is most desirable, and this seemed to be secured when the view taken by Linnæus was adopted by the elder DeCandolle and followed "by Mohl, Palm, A. Braun," Alph. DeCandolle, "and other observers." Still the opposite view is now coming in, and if it should prevail against such an array of authority it must be because it proves more convenient and sensible in practice. From an article in the Gardeners' Chronicle for January 13, last, we learn that the subject was taken up by M. Alph. DeCandolle (whose judgment would always be much deferred to) at a recent meeting of the Botanical Society of France. As we have seen no report at first hand, we make the following extract from the Gardeners' Chronicle. It purports to represent the view and the reasoning of another excellent botanist, A. Braun:

"Professor Braun remarks that the best way to follow in determining the direction of the spiral is to follow the indication of the object itself. It is the animal or plant which ascends or descends, or goes to the right or the left. Again, in the case of an animal the position of an observer is of no consequence. We can distinguish the right and left sides of the animal, not from our position in relation to it, but according to the conformation of the animal itself. The animal cannot speak to us and tell us which is his left and which his right flank, but we, speaking animals, are able to do so."

That is to say, the animal—or rather the vertebrate animal—having front and back, has consequently a right side and a left. But the stem of a plant has none of these relations, neither front nor back, therefore neither right nor left. When we predicate right or left of a stem, or of a flower-bud, obviously it is the right or left of a viewing person. DeCandolle's illustrations concede this, although that of Braun ignores the distinction. When "in the case of a river the universal practice is to call the left bank that to the left hand of an observer supposed to be following the natural onward course of the stream," this is because it is more natural to go with the current, and it is the traveler's not the river's, right that is designated. So the difference between the two schools in the case in hand resolves itself into the position which the observer is supposed to occupy. "M. DeCandolle," following Linnæus, "supposes himself in the center of the coil" in the case of a twining stem. Bentham and Darwin suppose themselves on the outside,—a more feasible position, as it seems to us, and its naturalness is recognized by the mechanic, who everywhere regards the common screw as a right handed screw. and that in which the spiral rises towards the left of the outside observer as a left handed screw. If this is the natural way to look at a screw, why not the natural way to look at a twisted stem, or a coiled stem? Wherefore we conclude that this way of regarding the case, as practiced by Bentham and Darwin, is coming into vogue in spite of Linnæan authority, on account of its intrinsic reasonableness and convenience. A. G.

2. *A Botanical Necrology* of 1876.—The list is headed by the distinguished name of

ADOLPHE THEODORE BRONGNIART, who died in January, 1876, just when he had completed the 75th year of his age. The long list of his publications began in the year 1820, and was interrupted only at his decease, his latest communications to the Academy of Sciences and to the Botanical Society of France being in the year 1875. Some interesting investigations in fossil botany, which were in hand when he succumbed, are left unfinished. The Bulletin of the Botanical Society of France, under date of Feb. 25, contains the touching and instructive funeral discourses pronounced by his colleagues Duchartre, Decaisne, Bureau, Jourdain, Chatin, and others.

JOHN JOSEPH BENNETT, the associate of Robert Brown in all the latter part of his life, and his successor as keeper of the Herbaria of the British Museum, up to the close of the year 1870, was born January 8, 1801, and died Feb. 29, 1876. He was one of the best and most amiable of men, one of the most learned and the most modest; and his writings, like those of his master, Robert Brown, have an importance greatly exceeding their number and pretension. There is a biographical notice in Trimen's Journal of Botany, with a good portrait.

Christian Gottfried Ehrenberg, whose death, on the 22d of June, at the age of 82, was duly announced in this Journal, must also be counted among the botanists, against his early convictions as respects his life-long work upon the Diatomaceæ, and some of his earliest papers relate to Phanerogamic Botany. His earliest botanical paper bears the date of 1820.

Leopold Fückel, the Mycologist, author of the classical Fungi Rhenani Exsiccati, died at Vienna, May 8, 1876.

Edward Newman, who died, near London, June 12, 1876, at the age of 75, was better known as a zoologist than as a botanist, but is to be remembered among the botanists and amateurs for his well-known History of British Ferns, which has passed through four editions, and as the principal editor of the Phytologist, from 1841 to 1854.

Joseph Carson, M.D., long the professor of Materia Medica in the University of Pennsylvania, died at Philadelphia, December 30, at the age of 68. He was an active general botanist in his earlier years. Later his attention in this line was mainly directed to the history of medicinal plants, especially those of America. In lore of this kind he had no superior, at least since the premature death of Hanbury, and in this country he leaves no equal. He was an excellent teacher, a firm friend, and a most estimable man. Dr. Carson was one of a considerable circle of botanists, whose acquaintance the present writer made at Philadelphia more than forty years ago, of which there is now only one survivor, and he no longer a resident of Philadelphia. A good notice of Dr. Carson was contributed to the January number of the Bulletin of the Torrey Botanical Club, by its worthy President. In it the portrait of F. André Michaux, which has for many years adorned Dr. Carson's study, is referred to as "so far as known, the only likeness of that botanist extant." It may be worth while to record, that the writer of the present notice is the possessor of a daguerreotype likeness of the younger Michaux, taken in Paris a year or two before his death, and from which a photographic copy has subsequently been taken.

Wilhelm Hofmeister, the distinguished vegetable anatomist, successor of Von Mohl in the chair of Botany at Tübingen, as we learn, died on the 12th of January last. A. G.

3. *Mistletoe* (*Viscum album* Linn.)—MM. Grandeau and Bouton, in chemical examinations of the mistletoe, find that the stem differs essentially in composition from that of the tree on which it grows, and varies with the species; it contains much more potash and phosphoric acid than its supporting tree and much less lime,

and seems to live on the tree like a plant on its soil.—*Comptes Rendus*, Jan., 1877; *Nature*, Jan. 25, 288.

4. *Observations on Rhizopods.*—Prof. LEIDY stated that last July, in the sphagnum swamps of Tobyhanna, Pocono Mt., Monroe Co., Pa., he noticed an abundance of a Rhizopod which he thought he had not previously seen, and which he at first supposed to be an undescribed species, but which he now viewed as a variety of *Hyalosphenia ligata.* From this, as previously described, it differs in the test being of a pale sienna color, and perhaps of greater thickness, but otherwise is like it. The test is compressed pyriform, with the length and breadth nearly or about equal, and the thickness one-half. The lateral orders are obtusely rounded. The mouth is transversely oval. The sarcode is colorless, and attached to the inside of the test by diverging threads. The pseudopods are usually from two to three. Measurements, ·08 mm. long and broad, and ·036 thick, with the mouth ·02 broad and ·008. Others varied from ·06 long and ·08 broad, to ·092 long by ·064 broad.

In observing the Pocono variety of *Hyalosphenia ligata*, and the beautiful and well-marked species *Hyalosphenia papilio*, he detected an important point of structure which previously had escaped his notice. In the active condition of these, and other Difflugians, they are seen with one or more pseudopods extended from the mouth of the test, to the margin of which the sarcode is attached, as well as by diverging threads to various points of the interior of the test. The interval between the body of the sarcode and the interior of the test is occupied with water. The extent of the interval increases with the increase in number and extent of protrusion of the pseudopods, and also varies according to the degree of emptiness or repletion with food of the sarcode body. When the pseudopods are withdrawn into the mouth of the test, the mass of the sarcode expands in a corresponding ratio, and the threads of attachment to the inside of the test contract in length. The intervening water appears to be displaced through small apertures of the lateral borders and fundus of the test, which exist in numbers usually from two to half a dozen or more.

While speaking of Rhizopods, he would ask the attention of the Academy to some remarks on recent observations on the habits of several species of Amœba.

One of the species of Amœba which he had most commonly seen, he took to be the *Amœba verrucosa* of Ehrenberg, with which the *A. natans* of Perty, and the *A. terricola* of Greef, appeared to him to be synonymous. This species he had found in many places: in the crevices of the brick pavement in the yard attached to his residence, in brick ponds, in the ooze of the rocky shores of the Schuylkill River, in sphagnum swamps, in marsh mud, etc. It is remarkable for its sluggish character; and in appearance reminds one of a little pile of epithelial scales, or fragment of dandruff from the head. Appearing quadrately oval or rounded, transparent, and more or less wrinkled, or marked with delicate wavy lines; the pseudopods rise in short obtuse mammillary eminences or wave-like ridges, the summits of which are composed of transparent ectosarc, while the central portion of the body is occupied by a thin, pale, diffused, and finely granular entosarc. This contains one or more vesicles, usually one, which very slowly enlarges, and then less slowly collapses. In addition, as part of the structure, an oval granular nucleus is sometimes visible. The food contents generally appear not to be abundant, and often the creature appears to be empty of food altogether. The character of its food is the same as with other species of Amœba. It not unfrequently feeds on Difflugians. In a specimen from sphagnum water, from Vineland, N. J., last August, he observed an individual, about the $\frac{1}{10}$ of a millimeter, containing a Difflugia and a Trinema together. As observed by him, the species ranges from $\frac{1}{25}$ to $\frac{1}{8}$ of a millimeter in diameter.

On the morning of August 27, from some mud adhering to the roots of *Sparganium*, obtained the day previously in a nearly dried-up marsh, at Bristol, Pa., he obtained a drop of material for examination with the microscope. After a few moments he observed an *Amœba verrucosa*, nearly motionless, empty of food, with a large central contractile vesicle, and measuring $\frac{1}{25}$ of a millimeter in diameter. Within a short distance of it, and moving directly toward it, was another and more active Amœba, the species of which he was not positive. It was, perhaps, the one described by Dujardin as *A. limax*, by which name, for the present purpose, it may be called. As first noticed, this Amœba was limaciform, $\frac{1}{8}$ of a millimeter long, with a number of conical pseudopods projecting from the front broader end, which was $\frac{1}{16}$ of a mm. wide. The creature contained a number of spherical food vacuoles with sienna-colored contents, a large diatome filled with endochrome, besides several clear vacuoles, a posterior contractile vesicle, and the usual granular entosarc. The *A. limax* approached and came into contact with the motionless *A. verrucosa*. Moving to the right, it left a long finger-like pseudopod curved around its lower half, and then extended a similar one around the upper half until it met the first pseudopod. After a few moments the ends of the two pseudopods actually became connate (the second time he had observed this phenomenon), and the *A. verrucosa* was inclosed in the embrace of the *A. limax*. The latter assumed a perfectly circular outline, and after awhile a uniformly smooth surface; but the central contractile vesicle remained in the same condition, nor did he once observe it enlarge or collapse. The *A. limax* now moved away with its new capture, and after a short time what had been the head end contracted, became wrinkled and villous in appearance, while from what had been the tail end a number (ten) of conical pseudopods projected. The *A. verrucosa* assumed an oval form, and the contractile vesicle became indistinct, without collapsing. Moving on, the *A. limax* became more slug-like in shape, measuring about $\frac{1}{4}$ mm. long, by $\frac{1}{25}$ mm. broad. The *A. verrucosa* now appeared inclosed in a large oval clear vacuole, was constricted so as to be gourd-shaped, and had lost all traces of its contractile vesicle. Subsequently, the *A. verrucosa* was doubled upon itself; and at this period, the *A. limax* discharged from one side of the tail end, the siliceous case of the diatome, which now contained only a shrivelled cord of endochrome. Later the *A. verrucosa* was broken up into five spherical granular balls, and these gradually became obscured and apparently diffused among the granular contents of the entosarc of the *A. limax.* At one moment the five granular balls derived from the *A. verrucosa* appeared to be contained in three vacuoles, and the *A. limax* had a more contracted and radiate form, and then measured $\frac{1}{12}$ mm. in diameter.

The observation, from the time of the seizure of the *A. verrucosa* to its digestion, or disappearance among the granular matter of the entosarc of the *A. limax*, occupied seven hours.

From naked Amœbæ, the test-protected Rhizopods were no doubt evolved, and it is a curious sight to observe them swallowed, home and all, to be digested out of their home, just as the contents of diatomes are digested. It was also interesting to observe the cannibal Amœba swallowing another, and appropriating its structure to its own, just as we might do a piece of flesh, completely, without there being any excrementitious matter to be voided.—*Proc. Acad. Nat. Sci. Philad.*, 1876, 197.

5. *Habits of Formica rufa.*—Mr. McCook, speaking of the habits of *Formica rufa*, stated that the ants descending the tree-paths, with abdomens swollen with honey dew (called by him *Repletes*), were arrested at the foot of the trees by workers from the hill seeking food. Galleries communicating with the hill, opened at these points, around and in which numbers of ants were huddled engaged in drawing or bestowing rations of honey-dew. Similar commissary stations were found under the stones near by. The replete reared upon her hind legs, and placed her mouth to the mouth of the pensioner, who assumed the same rampant posture. Frequently two, sometimes three pensioners were thus fed at once by one replete. Apparently the workers engaged in building at the hill and galleries had thus resorted to these feeding places to obtain ordinary food, in the same manner that queens, males, and young ants receive it, viz: by disgorgement from the abdomens of repletes. The latter commonly yielded the honey-dew complacently, but sometimes were seized and arrested by the pensioners, occasionally with great vigor.

A number of experiments were described leading to the conclusion that there was complete amity between the ants of a large portion of the field, embracing some 1600 hills and countless millions of creatures. Insects from hills widely separated always fraternized completely when transferred. A number of ants collected from various hills fraternized in an artificial nest, harmoniously building galleries and caring for the cocoons.

It was found that ants immersed in water when replaced upon the hills were invariably attacked as enemies; the assailants, being immersed, were themselves in turn assaulted. A number of experiments were made which indicated that the bath had temporarily destroyed the peculiar odor or other property by which the insects recognized their fellows.

The variety of *F. rufa* which had colonized in vast numbers on the cliff at Rockland opposite the steamboat landing, as observed for the last three summers, were found that morning to have abandoned the place. No trace of them could be seen in the vicinity. The crowds of human beings who occupied the spot during the late International regatta had evidently dispersed the republic.—*Proc. Acad. Nat. Sci. Philad.*, 1876, p. 200.

6. *The Rhynchophora of America, north of Mexico;* by JOHN L. LECONTE, assisted by GEORGE H. HORN. 456 pp. 8vo, constituting vol. xv (December, 1876) of the Proceedings of the American Philosophical Society.

7. *A new Echidna* (*Tachyglossus*) *from New Guinea.*—The new species has its rostrum half longer (the length about 6·4 inches) than either that of the species from southeastern Australia or that from Tasmania. It is named *Tachyglossus Bruijnii* by Peters and Doria in a paper published at Genoa.—*Nature*, Jan. 18.

IV. ASTRONOMY.

1. *A New Planet;* C. H. F. PETERS. (From letters of January 22 and 31, dated Litchfield Observatory of Hamilton College, Clinton, N. Y.)—On the 17th instant, I saw a planet unknown to me in the position approximately of $8^h\ 34^m\ 55^s$ of R. A., and $+17°\ 52·7'$ Decl.; but the weather thickened so that an accurate position could not be obtained before last night, when at ten o'clock the stranger was in $8^h\ 30^m\ 20^s$ of R. A., and $+17°\ 42'$ Decl. (the reductions having not yet been fully completed). Hence the motion was in four days $4^m\ 35^s$ and $-11'$. The magnitude I estimated the 11th.—(Letter of Jan. 22.)

From LeVerrier's *Bulletin International* of January 12, just received, I see that the planet I gave you notice of on the 22d instant, had already been found at Toulouse, on January 10. But through neglect somewhere, the usual notification by telegraph,—as has been customary between European and American astronomers during recent years, and for which the Atlantic Cable Company has made a liberal concession,—has not reached us.

I communicate two more observations,—all that weather and moonlight have permitted since the 21st,—each from ten comparisons with stars well determined:

1877.	Mean time.	a (170).	δ (170).
Jan. 23.	$9^h\ 50^m\ 45^s$	$8^h\ 27^m\ 59·40^s$	$+17°\ 35'\ 24·8''$
" 26.	$11^h\ 48^m\ 51^s$	$8^h\ 24^m\ 23·42^s$	$+17°\ 26'\ 15·0''$

—(Letter of January 31.)

2. *Instruments and Publications of the U. S. Naval Observatory.* Rear Admiral C. H. DAVIS, Superintendent. Washington, 1845–1876. Published by authority of the Hon. Secretary of the

Navy. 44 pp. 4to, with six plates.—After a brief account of the founding of the Observatory, its library, and its position, the several instruments are described, the Mural circle and Transit instrument mounted in 1844, the Prime Vertical Transit Instrument and 9·6 inch Equatorial mounted in 1845, the Transit circle mounted in 1865, and the 26-inch Equatorial mounted in 1873, and to the descriptions are added heliotype representations of the instruments.

3. *Note of the recent fall of three Meteoric Stones, in Indiana, Missouri, and Kentucky;* by J. LAWRENCE SMITH, Louisville, Ky. (Communicated.)—Three meteorites were seen to fall inside of a comparatively small region of the United States within the space of about one month. These falls were accompanied by some interesting phenomena, and in the case of the fall of the twenty-first of December, the appearance of the bolide from which it came was truly magnificent, and was seen over a large tract of country, from west to east. My object at the present time is simply to announce these falls, reserving for a future communication fuller details, when I have completed their chemical and mineralogical examinations. I will then call attention to an interesting aërolitic belt in this country, in which a very large number of meteorites have fallen during the past sixteen years.

No. 1, fell on December twenty-first, 1876, at 8^h, 40^m, P. M. This remarkable bolide was seen to pass over the States of Kansas, Missouri, Illinois, Indiana and Ohio—a distance from east to west of about 800 miles. It burst into numerous fragments during its passage, producing "a flock of brilliant balls, chasing each other across the sky, the number being variously estimated from twenty to one hundred." The passage of it is described in this Journal for February, 1877. A piece from this bolide, of a few ounces in weight, has been found near Rochester, in Indiana, latitude 41° 8′, longitude 86° 12′, and I have received a portion of it for examination.*

No. 2. On January third, 1877, at sunrise, in Warren County, Missouri, latitude 38° 50′, longitude 91° 10′, the usual phenomena accompanying the falls of meteorites attracted the attention of several observers, who saw the stone strike the branch of a tree, (which it broke), then fall to the ground, penetrating it slightly, and melting the snow that lay on its frozen surface. It was picked up immediately after, and a portion of it has been sent to me for examination.

No. 3. On January twenty-third, 1877, in the afternoon, a few miles north of Cyntheana, Ky., latitude 38° 25′, longitude 84° 15′, a meteoric stone was seen to fall, accompanied by great atmospheric disturbance, penetrating the ground to the depth of thirteen inches. There was an observer on the ground near the spot where it fell, and he immediately dug it up. It weighs about fifteen pounds.

Louisville, Ky., February 6.

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* This is the meteorite which is the subject of Professor C. U. Shepard's article, on page 207.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Topographical Survey of the State of New York.*—As announced in a former volume of this Journal, this survey was commenced last year, under Mr. James T. Gardner as Director. This event, which had been recommended by the Geographical Society of New York, appeared to be a promise that topographical surveys were now to be carried on over the country which would soon put the nation on a level with those of Europe in its maps, and in its knowledge of its own industrial resources. But the recent recommendation of the Governor of New York threatens a stop to the work, and a still longer continuance of faulty maps, uncertain lines of roads and boundaries, unknown water-privileges and drainage areas, and general topographical ignorance. A petition in favor of the survey has been addressed to the legislature by the New York Geographical Society, and the Faculties of Columbia College, the Polytechnic Institute of Troy, and other institutions, and the editors of this Journal hereby send their petition to the same effect.

2. *Tour of the Great Lakes: Summer School of Natural History.*—Professor T. B. Comstock of Cornell University, proposes "if sufficient encouragement be given prior to May 1," to charter a steamer for a period of four to six weeks, and start from Buffalo or Cleveland, about July 5th, on a tour along the shores of Lakes Erie, Huron and Superior, and possibly also Lake Michigan. Competent instructors in geology and botany are to be engaged, and lectures from specialists are promised. The prospectus states that the expenses will not exceed $125 for thirty days and $3.50 for each additional day. The trip will be limited to thirty days unless a majority vote of the pupils decides otherwise.

3. *Elements of Physics, or Natural Philosophy;* by NEIL ARNOTT, M D., LL.D., F.R.S. Seventh edition. Edited by Alexander Bain, LL.D., and Alfred Swaine Taylor, M.D., F.R.S. 873 pp. 8vo. New York, 1877. (D. Appleton & Co)—The first edition of the "Elements of Physics" by Dr. Arnott appeared in 1827, and within four years from that time five large editions were called for. The author himself died in March, 1874, but his work still lives, with the same popularity which it had on its first appearance. Its especial excellence lies in its clearness of style and fullness of illustration. Each new principle is enforced by many familiar examples, which remove the difficulties that the student would be likely to find in understanding it if stated in a dry formal way. The book consequently is throughout eminently interesting and readable, even for those who have no special knowledge of the science. Under the editorship of Professor Bain and Dr. Taylor, the new edition of the work is made to include the recent advances in the science.

4. *Metric System. Metric Bulletin.*—This bulletin, the official Journal of the "American Metric Bureau," is issued in Boston, from 13 Tremont Place. Nos. 3 and 4 were issued together, as the number for September and October, 1876.

In December, a report was published by the Boston Society of ivil Engineers, from “the Standing Committee on the Metric ystem of Weights and Measures,” urging the general adoption f the system and giving various facts indicating the great prog-ess which has been made in the country toward that end.

It is expected that the metric system of weights will soon be xclusively used in the Post Office Department of the country; nd hoped that it may be introduced into the Custom House, as as been urged for some time by the American Metrological ociety. These are the best first steps in the change; and when nce carried out, and teachers do their duty in common schools, he change may become general. Compulsory for the people at rge it cannot be at present.

5. *Illinois Museum of Natural History.* Bulletin No. 1. 76 p. 8vo.—This first Bulletin, devoted to the Natural History of llinois, contains the following papers: A list of Illinois Crustacea, y S. A. Forbes; The tree in Winter, by F. Brendel; Sodic Pinate as a test for lime, by J. A. Sewall; partial catalogue of he fishes of Illinois, by E. W. Nelson; on parasitic Fungi, by T. J. Burrill; list of the Orthoptera of Illinois, by Cyrus Thomas.

6. *Huronian rocks of the Lake Superior region described by Major Brooks.*—Thin sections of these rocks, for microscopic examination, are prepared by R. Fuess, of Berlin, and may be obtained at a small price. The collection contains thirty sections.

7. *Third Annual Report of the Commissioner of Agriculture of the State of Georgia,* for 1876.—Besides various facts of local mportance, this report gives analyses of marls from different beds, and also of other mineral materials, by P. H. Mell, chemist.

8. *The Applications of Physical Forces;* by AMEDÉE GUILLEMIN. Translated from the French by Mrs. Norman Lockyer, and edited, with additions, and notes, by J. Norman Lockyer, F.R.S. 742 pp. Roy. 8vo, with colored plates and illustrations. London, 1877. (Macmillan & Co.)—This work on physics with special reference to its applications, is an example of science well simplified and popularized. The editorship of Mr. Lockyer is a sufficient warrant that the science is good. The style of publication is seldom equalled for beauty in scientific works, the typography, paper, and very numerous illustrations being the best that art can accomplish. It treats, under “applications of the laws of weight,” of levels, pendulums, balances, hydraulic presses, fountains, pumps, fire-engines, atmospheric railways, compressed-air railways, balloons, etc., etc.; and similarly looks to the practical under applications of the phenomena and laws of sound, of light, of heat, of magnetism and electricity. Under heat, the art of warming is first treated historically and practically; then practical points arising from the conductibility of heat, burning glasses, compensating pendulums, distillation, artificial preparation of ice, steam engines of various kinds, steam navigation, the locomotive, hot-air and gas-engines. The work, therefore, is not only attractive in appearance, but also of real value.

Science Lectures at South Kensington. A valuable series of lectures, published separately, including: *Sound and Music*, by Dr. W. H. Stone; *Photography*, by Captain Abney, R.E., F.R.S.; *Kinematic Models*, by Prof. Kennedy, C.E. London and New York; *Outlines of Field-Geology*, by Prof. Geikie; *The absorption of light and the colors of Natural bodies*, by Prof. Stokes. 1875, 1877. (Macmillan & Co.)

Manchester Science Lectures for the People: *What the Earth is composed of*, three lectures by Professor Roscoe, F.R.S. London and New York. 1876. (Macmillan & Co.)

OBITUARY.

Rear Admiral **Charles Henry Davis** died on the eighteenth of February, at the age of seventy years, having been born in Boston, January 16, 1807. Admiral Davis was Superintendent of the Naval Observatory at Washington at the time of his decease, and also one of the members of the Light House Board. He became Superintendent of the "American Nautical Almanac" in 1859, the foundation of which was directly owing to his efforts. From 1842 to 1849 he was an Assistant in the Coast Survey; and one result of his labors, of great value to navigation, was the discovery of the "New South Shoal" in the track of vessels sailing from New York to Europe; and another was the publication of a "Memoir upon the Geological action of the tidal and other currents of the ocean, and the Law of deposit of the flood tide," prepared after having made a special study along the Atlantic coast of the laws of tidal action. He was the author also of several able articles on astronomy and geodesy, and published in 1858 a translation of Gauss's "Theoria Motus Corporum Cœlestium."

Rear Admiral **Charles Wilkes** died on the eighth of February, in the seventy-seventh year of his age. Admiral Wilkes, then a Captain, commanded the United States Exploring Expedition around the world during the years 1838 to 1842, and published, after its return, a narrative of the expedition in five volumes, a hydrographic atlas, containing the maps from the various surveys of the expedition (among which are many of coral islands), and a meteorological volume. He was a bold, daring explorer, a man of strong will and great energy, sure to accomplish whatever he undertook. His sailing up Port Jackson, the port of Sydney, New South Wales, an intricate narrow bay, seven miles in length, one dark night in November, 1839, without pilot, in company with the Peacock, the other sloop of war of the expedition, picking his way along with the lead and chart, and coming to anchor quietly among the shipping of that harbor without arousing a suspicion of the foreign invasion in progress, was one of his daring feats.

Alfred Smee, the inventor of "Smee's Battery," for which he received the gold medal of the Society of Arts, and the author of works on electro-metallurgy, electro-biology, and other subjects, died on the 11th of January, in his 59th year. He was elected a Fellow of the Royal Society at the early age of twenty-one, and, among his many offices, was Surgeon to the Bank of England.—*Nature*, Jan. 25.

Professor J. C. **Poggendorff**, editor of the Annalen der Physik und Chemie since January, 1824, and long Professor in the University at Berlin, died the last week of January, in his eighty-first year.

THE

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[THIRD SERIES.]

ART. XXVI.—*Note on the Sensation of Color*; by C. S. PEIRCE.

IT may, perhaps, be worth while to notice a few consequences of three theories concerning color which are usually regarded with some favor.

First hypothesis.—The appearance of every mixture of lights depends solely on the appearances of the constituents, without distinction of their physical constitution. This I believe is established.

Second hypothesis.—Every sensation of light is compounded of not more than three independent sensations, which do not influence one another. This is Young's theory. It follows that, if we denote the units of the three elementary sensations by i, j, and k, every sensation of light may be represented by an expression of the form,

$$Xi + Yj + Zk.$$

Third hypothesis.—The intensity of a sensation is proportional to the logarithm of the strength of the excitation, the barely perceptible excitation being taken of unit strength. Negative logarithms are to be taken as *zero*. This is Fechner's law. It is known to be approximately and only approximately true, for the sensation of light. From this it follows that, if x, y, z be the relative proportions of a mixture of three lights giving the elementary sensations i, j, k, the sensation produced by the mixture is

$$\mathrm{I} \log x . i + \mathrm{J} \log y . j + \mathrm{K} \log z . k,$$

where I, J, K, are three constants.

From these principles, it follows that if a light giving any sensation such as that just written have its intensity increased in any ratio r, the resulting sensation will be,

AM. JOUR. SCI.—THIRD SERIES, VOL. XIII, NO. 76.—APRIL, 1877.

$$\mathrm{I}\log rx.i+\mathrm{J}\log ry.j+\mathrm{K}\log rz.k=$$
$$\mathrm{I}\log x.i+\mathrm{J}\log y.j+\mathrm{K}\log z.k+\log r\,(\mathrm{I}i+\mathrm{J}j+\mathrm{K}k).$$

Thus, the result of increasing the brilliancy of any light must be to add to the sensation a variable amount of a constant sensation, $\mathrm{I}i+\mathrm{J}j+\mathrm{K}k$. And all very bright light will tend toward the same color, which may therefore be called the *color of brightness.* Moreover, if the three primary colors be mixed in the proportions which each by itself is just perceptible, the sensation produced will be

$$\log r\,(\mathrm{I}i+\mathrm{J}j+\mathrm{K}k),$$

and can only differ by more or less.

Now I find, in fact, that all colors are yellower when brighter. If two contiguous rectangular spaces, illuminated with the same homogeneous light, uniformly over each, but unequally in the two, they will appear of different colors.

If both are *red* the brighter will appear *scarlet;*
" " *green* " " *yellowish;*
" " *blue* " " *greenish;*
" " *violet* " " *blue.*

If we have the means of varying the wave-length of the light which illuminates the fainter rectangle, we can improve the match between the two, by bringing the fainter toward the yellow. Such motions will converge toward a certain point of the spectrum which they will never cross,—a point a little more refrangible than D and having a wave length of $582 \cdot 10^{-6}$ mm., according to Ångström's map. If both rectangles be illuminated with this light, the fainter appears white or even violet, but if it be varied in wave-length with a view of improving the match, it will be found to return to the same point with the utmost precision.

It appears, therefore, that, if our hypotheses are correct, the color $\log r\,(\mathrm{I}i+\mathrm{J}j+\mathrm{K}k)$ is like that of the spectrum at $\lambda=582$, only that it contains less blue or violet and is consequently of greater chromatic intensity.

It further follows from Fechner's law that, if any light be gradually reduced in brightness, one element of the sensation will disappear after another; and that when very faint it will exhibit only one primary color, which is the one which it contains in greatest proportion relatively to the proportion in the light which has the color of brightness. Now, although this does not seem to be exactly the case, yet we do get some approximation to it. It is true that any light whatever, when sufficiently faint, appears white, owing to the self-luminosity of the retina. We cannot, therefore, unfortunately, get sight of the primary colors by reducing the light of three parts of the spectrum. But we may, as has often been suggested, make use of the principles of contrast. If any red spectral light be sufficiently reduced, it will perfectly match any less refrangible light. We may, therefore, say that a faint spectral red in contrast with a bright light of the same kind, excites with approximate purity one of the elementary sensations. The same thing is true of the violet; and therefore a rich violet may be taken as another primary color. In my book entitled Photometric Researches, the printing of which is nearly complete, I show reason to think that the pure green has a wave length intermediate between E and b. A faint green of this sort contrasted with a bright one appears as a very bluish green, and this may therefore be supposed to be the third primary color.

We have seen that it results from the theory that an increase in the brilliancy of any light adds to the sensation nothing of the peculiar color of that light, but only a certain amount of the color of brightness. If this be the fact, then the photometric sensibility of the eye should be the same for all colors. In order to ascertain whether this is so or not, I have made a series of determinations of my photometric probable error. Each determination was based on twenty-eight comparisons of two parts of the same colored disk. Since there were two unknown quantities, namely, the relative brightness of the two surfaces compared, and an instrumental constant, it follows that only twenty-six observations were effective for determining the probable error. Let R be my photometric probable error of a single comparison. Then the probable error of a single determination of R (which we may denote by r) would be $\frac{\cdot 51}{\sqrt{26}} \times \text{R}$, or say $\frac{1}{10}$R. Having made a considerable number of such determinations of R, with different colored disks, let us ascertain their probable error from their discrepancies, considering them as so many independent observations of the same unknown quantity, and denote this probable error by r'. If, then, R really is the same for all colors, we should have

$$r' = r,$$

or, at least, the difference should not exceed ρ, the probable error of r'; which may be calculated by the formula

$$\rho = \frac{\cdot 51}{\sqrt{m} r'},$$

where m is the number of sets of experiments diminished by 1. If, on the other hand, R varies with the different colors, and not merely accidentally, r' should have a larger value. The following are the values I obtained for R, the sum of the brightness of the two surfaces compared being taken as unity.

		R.	Diff. from mean.
Feb. 6.	White	·0041	+·0001
	Red, just before C	·0046	+·0006
	Chrome-yellow, A 2	·0032	−·0008
Feb. 7.	Red, just before C	·0040	±·0000
	Staat's emerald green	·0046	+·0006
	Carmine, B	·0044	+·0004
	Chrome-yellow, A 1	·0037	−·0003
	Purple, Hoffmann's violet RRR	·0033	−·0007
Feb. 13.	Red, just before C	·0048	+·0008
	Green, complementary to carmine	·0034	−·0006
	Blue violet, No. 2	·0048	+·0008
	Yellow, A 1, mixed with black	·0032	−·0008
	Mean	·0040	

After these experiments, the method of observing was change and I obtained the following:

Feb. 14.	White window-shade, ill. by sun	·0030	−·0002
	Brown	·0030	−·0002
	Greenish sky-blue	·0037	+·0005
	Very reddish purple	·0028	−·0004
	Yellow orange	·0032	±·0000
Feb. 15.	"Fundamental green of Müller"	·0030	−·0002
	Vermilion, half between C and D	·0034	+·0002
	Violet	·0032	±·0000
	Yellow	·0036	+·0002
	Mean	·0032	

We thus get from the

first twelve determinations, $r = {\cdot}00040,\ r' = {\cdot}00048,\ \frac{r'}{r} = 1{\cdot}2$

last nine determinations, $r = {\cdot}00032,\ r' = {\cdot}00019,\ \frac{r'}{r} = 0{\cdot}6$

and from the weighted mean, $\frac{r'}{r} = {\cdot}96$, so that it appears fr these experiments that the photometric susceptibility of the e is the same for all colors. The result is, however, uncerta because it may be that R is chiefly due to other sources of er than the limitation of sensibility; still, the experiments show small a value of R as is usually obtained. I shall endeav by further observations, to obtain a conclusive result.

A further consequence of our hypotheses will be reached differentiating the expression for a light-sensation. We ha

$$d(\mathrm{I}\log x.i+\mathrm{J}\log y.j+\mathrm{K}\log z.k)=\frac{1}{x}dx.\mathrm{I}i+\frac{1}{y}dy.\mathrm{J}j+\frac{1}{z}dz.\mathrm{K}$$

Now, as x, y and z all exceed unity, the differential is greater arer unity x, y and z are. Hence, since the variation of the oportions of the primary colors with a variation of postion in e normal spectrum is uniform,* it follows that the change of lor of the normal spectrum should be most rapid about $\lambda=582$, it of course is. It is also obvious that if the total quantities the three colors are nearly the same in different parts of the ectrum (I here refer to these colors not as really objective, it as measured in the usual objective way) then the part about $=582$ must be the brightest, another familiar fact.

I may observe that there is a modification of our formula for sensation of light, which probably better represents the rela- ons of the sensations. Writing, in the first place,

$$\mathfrak{i}=\mathrm{I}i \qquad \mathfrak{j}=\mathrm{J}j \qquad \mathfrak{k}=\mathrm{K}k$$

e formula is

$$\log x.\mathfrak{i}+\log y.\mathfrak{j}+\log z.\mathfrak{k}.$$

is loses its validity when any of the logarithms become neg- ive. If z is the smallest of the three quantities, we may sub- tute

$$\mathrm{X}=\frac{x}{z} \qquad \mathrm{Y}=\frac{y}{z}$$

d the formula becomes

$$\log \mathrm{X}.\mathfrak{i}+\log \mathrm{Y}.\mathfrak{j}+\log z\,(\mathfrak{i}+\mathfrak{j}+\mathfrak{k}).$$

hen x or y is smallest there will be two other formulæ. ow, as the variation in the brilliancy of the light affects only e last term of the last formula, and not the first two depend- g on X and Y, it is more than probable that the eye is habit- ted to separating the element of sensation which this last rm represents, and which is continually changing its values, om the rest which remains constant. It is, therefore, likely at the classification of light into three kinds, according as the *olet*, the *red*, or the *green*, is contained in the smallest propor- on, is one which has a relation to the natural powers of scrimination.

My observations have been made with an instrument for ich I am indebted to the liberality of the trustees of the che Fund. I shall describe it on the occasion of publishing me work of a more serious character. The colored disks ade use of were very kindly lent me by Professor Rood.

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* I will show this in a note in the next number of this Journal.

ART. XXVII.—*Note on the Binocular phenomena observed by Professor Nipher*; by JOSEPH LECONTE.

THE striking phenomenon described by Prof. Nipher, in the January number of this Journal, was described by Prof. W. B. Rogers, at the Newport meeting of the American Association, 1860, and may be found recorded in the 14th vol. of Proceedings, p. 197. It is only one of innumerable phenomena which are all explicable on the same general principles. The principles involved have been so fully set forth in several of my papers on binocular vision, especially in IV, "On a new method of representing visual phenomena," and VI, "On so-called images of illusion,"* that it is unnecessary to do more than briefly recall them here.

1. The field of view may be regarded as an outward projection of retinal states. As each eye has its own retina crowded with its own *retinal* images, so also each eye must have its own field of view and its own *external* images. There are therefore *two external images* for every object. These may be united, so as to see the object single; or may be separated, so as to produce the phenomenon of double images. *Moreover, the external images of different objects may also be* brought together and superposed at will. In all discussions of binocular phenomena, therefore, it is absolutely necessary that we speak not of objects but *of external images, the signs of objects.*

2. In binocular vision with the optic axes parallel, as in looking at a distant object, the whole visual field with all its external images or objects is shifted by the right eye a half interocular distance to the left, and by the left eye the same distance to the right; so that the two visual lines are brought together in the middle, and combine to form a common median visual line, and the *images of all objects in these lines are brought together and superposed.* This is the necessary result of the law of corresponding points. Retinal images of all objects in the visual lines fall on corresponding points, viz: the central spots; their external images are therefore thrown to the same place in space and are therefore superposed.

Now, in the experiment of Prof. Nipher, the visual line of the right eye passes through the axis of the tube and pierces the center of the circular visible area of the object regarded, while the visual line of the left eye pierces the left hand or paper-sheet or other object placed before it, at a point distant about 2½ inches (an interocular space) from the axis of the tube. Therefore the center of the circular area regarded by the right eye, and the spot on the hand or paper sheet pierced by the ft visual line, by the law stated above, *are brought together nd superposed.*

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* See this Journal, Jan. 1871, and Dec. 1871.

One thing more to complete the explanation. The impres-on on the right eye prevails over that of the left—the impression f the circular area *obliterates* that of the corresponding spot n the hand or paper sheet, for two reasons; first, because the rcular area is strongly differentiated from the rest of the right ye field of view (the dark interior of the tube) while the cor-esponding spot on the left-eye field is not thus differentiated; nd second, because both eyes are focally adjusted for the dis-ance of the object seen by the right eye only. Thus it comes pass, that the right eye sees *only the circular area*, the rest of its eld being very dark; while the left eye sees *all its field* xcept the spot covered by the circular area. But if an ink oot be placed on the hand or paper sheet just where the isual line pierces, then the first cause mentioned above will be emoved and the strongly differentiated ink spot will be seen the center of the circular area.

Berkeley, Cal., Feb. 7, 1877.

RT. XXVIII.—*Revision of the genus Belemnocrinus, and description of two new species;* by CHARLES WACHSMUTH and FRANK SPRINGER.

IN 1862, Dr. C. A. White described a type of Crinoids from e Burlington limestone of Iowa under the generic name *Be-mnocrinus*, of which he had discovered only a single species, *. typus.* The description, with a figure, was published in the roceedings of the Boston Society of Natural History, vol. ix, p. 3. Messrs. Meek and Worthen in the Report of the Geological urvey of Illinois, vol. iii, p. 463, described another species, *B. Vhitei* from a specimen having only the calyx preserved. Count ourtales, in the Illustrated Catalogue of the Museum of Com-arative Zoology at Harvard College, No. 8, p. 29, has made ome interesting observations upon the relations of *Belemnocrinus* the recent genus *Rhizocrinus*, and further expressed the opin-on that *Belemnocrinus* does not possess, as Dr. White supposed, ve small basal plates below the long plates which compose the reater portion of the calyx, but that these long plates are them-elves the true basals, thus exhibiting a very marked resem-lance to *Rhizocrinus.*

A careful examination of some recently acquired specimens f this genus, including two new species in an excellent state f preservation, and a comparison of these with the original pecimens heretofore described, afford us new light in regard to the structure of this interesting type of fossils, and it enables u to confirm the opinion of Count Pourtales, thereby rendering revision of the generic formula and description appropriate an necessary.

A specimen of *B. Pourtalesi*, W. & S., has been deprived o the column, and the lower part of the cup is somewha crushed, in such a manner that two of the long plates are separated along their entire length, exhibiting the sutures to th central perforation which leads into the column. The lowe extremities of these plates are excavated, forming a concavit for the insertion of the pentagonal column, the marks of it attachment in a pentagonal outline are plainly visible, thu proving beyond the slightest doubt that these long plates reste directly upon the column, and formed with the first radials, th cup which encloses the visceral cavity. From these facts i follows that the long pieces, which were considered to be subradials, both by the author of the genus and by Messrs. Mee and Worthen in their description of *B. Whitei*, must now b designated as basal plates.

Additional light has been thrown upon the construction o other-parts in this genus; every one of the four known specie is furnished with a strong proboscis, inflated toward the to and resting upon the single large anal plate which is a part o the wall of the cup. The exact structure of the summit of th calyx has not as yet been made out, but the comparativel massive character of the plates which compose the probosci as well as the size of that organ, render it altogether probabl that it was supported by a solid dome.

The arms, as observed in three of the four known species, a ten in number. They are provided with long, comparativel heavy pinnules, originating on the longer margins of larg wedge-form joints, which alternate with other joints of qua rangular outline, thus giving two rows of pinnules, alternatel arranged, to each arm. In both of our new species these pi nules are simple; while those of *B. typus* are furnished wi secondary pinnules, which are alternately arranged as the primary pinnules The arms of this genus bear in proportion and general aspect some resemblance to those of *Poteriocrinu* but they are in fact widely different. In *Poteriocrinus*, th arms divide upon a bifurcating plate or joint, into equal branche which rest upon the upper faces of this joint; while in *Belemn crinus* the branches are true pinnules, and not armlets, the spring from the long latteral margin of the syzygial joint, n from its upper side. We have in our possession a specime which in general aspect somewhat resembles *Belemnocrinus*, th elongated basal plates form here a cylinder apparently soli almost precisely similar to that of *B. typus*, and as the upp portion of the calyx is somewhat distorted by pressure, it was at first supposed to be a *Belemnocrinus.* Upon removing the calyx from the surrounding matrix and arranging the plates in their natural position, it was found to possess a series of large sub-radials resting upon the basals, the anal plates arranged as in *Poteriocrinus*, thus exhibiting a fundamental difference from *Belemnocrinus.* Careful examination of the interior part of the cylinder formed by the basal plates, showed that they are thin and enclosed a comparatively large cavity, reaching nearly to the bottom of the cup, thus proving in a highly satisfactory manner the value of the peculiar characters of *Belemnocrinus.*

We are unable to agree with Dr. White in referring this genus to the *Cyathocrinidæ*, as it does not possess the general appearance of that group, nor does it agree in the generic formula as herein given. The slender ovoid or cylindrical base, the long solid basal plates, the shallow cavity in their upper part, and the comparatively small size of the visceral cavity are features which remove *Belemnocrinus* far from *Cyathocrinus*, or any of its allied genera. These characters show its affinities rather with the Jurassic genus *Apiocrinus*, to which in the construction of the calyx and inner cavity, it is more similar and seems to bear a closer relation, than to any other known group.

The resemblance to the recent genus *Rhizocrinus*, pointed out by Count Pourtales, is very close and interesting, even more so than he perceived, since we cannot agree with him that the first radials are movable in *Belemnocrinus.* On the contrary we find them to be closely joined with each other and with the anal plate by exact sutures, the anal plate being in line with them, forming the cup, and supporting upon its upper face the heavy proboscis. The succeeding radials have spaces between the rays, showing them to have been free. The most important difference, and indeed the only essential distinction between these genera in their external structure is found in the solid proboscis and covered dome of *Belemnocrinus.*

As a result of the foregoing observations we give now the following revised

GENERIC FORMULA.

Basal plates, five; long, narrow, forming an ovoid to cylindrical cup, which is nearly solid, having a small central perforation, and a shallow subconical excavation at its upper end, which forms a part of the visceral cavity.

Radial plates, four to five × 5; the first series with the anal plate joined at the sutures and composing a part of the cup; the succeeding radials free.

Anal plate, one; supporting a rather long, comparatively large proboscis. Dome covered by solid plates, arrangement unknown. Arms, ten so far as observed. Pinnules long and strong. Column pentagonal.

As yet found only in the Upper and Lower Burlington limestone.

The following species, new to science, have been discovered by us:

Belemnocrinus florifer, n. sp.

Smaller than *B. typus.* Column comparatively large, composed alternately of large and small joints, the smaller of which are nearly regular pentagons, and the larger pentagonal in outline, arched at the angles, notched in the middle of the sides making the column in general distinctly pentagonal, crenulated transversely, with a somewhat interrupted longitudinal furrow along the middle of each side. To the sixth and eighth large joint from the base, are attached radicular cirrhi which originate in the depressions or notches on each of the five sides of the joint. Traces of other sets of cirrhi are visible lower down on the column. They are all arranged precisely as those of *Pentacrinus Caput-Medusæ*, to the column of which this is in aspect strikingly similar. The cirrhi are long, slender, tapering to the tips, with joints longer than wide, and they increase in size as they approach the root.

The calyx is comparatively low, about two thirds as wide as high, ovoid below, turbinate and rapidly expanding above, constricted about the middle, with a deep transverse suture. The five basal plates are smooth, about three fourths as wide as high, slightly widest near the top, forming the ovoid portion of the calyx, gently expanding from the column outward and upward. They are constricted and abruptly truncated at the summit and appear as a heavy band around the lower part of a second cup which seems to rest in this one. The first radials are large, more than one half the size of the basals, a little higher than wide; outer surface strongly arched, curving rapidly inward at their junction with each other, thus forming deep vertical sutures. They compose, with the anal plate, a cup of conical shape whose sides are crenulated or scalloped by the arching of the plates and the depression of the sutures, and the diameter of which at the bottom is considerably less than that of the ovoid basal cup beneath, in which, rather than upon which, it seems to rest. The radials lie in a line with the sutures of the basals, and rest apparently upon the inner edges of the upper faces of these plates. The upper portion of this conical cup in turn projects outward in a rim or band enclosing the arm bases, the arms seeming to proceed from the inside, the calyx and arms thus presenting the peculiar appearance of a bouquet of flowers in a conical vase, which in turn rests in an egg-shaped cup truncated at the base, thus suggesting the specific name. The upper faces of the first radials are truncated, and upon their inner edges rest the free radials which are four in number, about one-fourth the size of the first radials, a little wider than high and of uniform dimensions up to the arms. The plates of this series are rounded, strongly constricted, transversely in the middle, expanding at their upper faces, producing a rim which envelopes the lower part of each succeeding piece, this rim or wrinkle being rather thicker and more prominent at the lateral margins. The fourth free radial is pentagonal in form, the two upper faces forming an obtuse angle and supporting the arms which are simple throughout their entire length, thus giving two arms to each ray or ten to the species. Arms comparatively very long, rounded, tapering very gradually to the tips, composed of joints which are constricted in the middle, marked by strong lateral wrinkles, thickened at the upper margin to embrace the succeeding joints just as in the free radials. In the lower part of the arms, apparently every third joint, is a syzygium, wedge-form in shape, with quadrangular joints between; while in the upper part the joints are alternately wedge-form, and to the longer margins of these joints the pinnules are attached. These syzygial joints are strong, prominent, and give to the arms an obtusely zigzag appearance. Pinnules simple, rather heavy, very long, directed upward, lying closely along the arms, composed of rectangular joints twice as long as wide, and of nearly equal size throughout their length. Anal plate, rather large, quadrangular in outline, its upper face in a line with the top of the first radials. From the inner part of the upper truncate face of this plate proceeds a proboscis, in height equal to three-fourths the length of the arms. The lower part is composed of large plates nearly equal in size to the free radials, longitudinally arranged, each one resting upon the upper truncate face of the preceding one. Proboscis slightly inflated, the upper part composed of small nodose plates irregularly arranged, while its summit is surmounted by a set of prominent spines whose arrangement cannot be exactly determined.

The entire surface, with the exception of the basal plates, (even the pinnules) is covered by strong wrinkles which produce a peculiar carinated style of ornamentation.

This species is so well marked, and so unlike any other described form, that it may be distinguished with the greatest ease. It differs from *B. typus* and *B. Whitei* in its shorter basal pieces, the extreme size of its first radials, and in the peculiar attachment of the first radials to the basals. In both these species, the suture between the basals and first radials is not prominent, and the latter plates form a continuation of the cylindrical basal portion, while in our species the depth of the transverse suture, the beveling and constricting of the uppe edges of the basals, gives to the basal portion the appearanc of enclosing the cup which is formed by the radials. It differ from those species also in the highly arched surface of the firs radials and the deep sutures between them, which give to th upper part of the cup its crenulated aspect. Also in the carinated surface. From *B. typus*, it further differs in the mod of attachment of the free radials and arm joints, the rim-lik projection at the upper face of each plate, and in the strongl pentagonal and crenulated column.

It differs from our species *B. Pourtalesi*, in most of the abov particulars and in the proportionally smaller size of its fre radials, in the succession of the syzygial joints, and in the simplicity of the pinnules.

The specimen from which our description is made, is in most perfect state of preservation, showing column, calyx, proboscis, and arms, the calyx being plump and every plate exactly in position.

Geological position and locality: from a thin cherty laye near the middle of the Upper Burlington limestone, Burlington Iowa. Collection of Charles Wachsmuth.

Belemnocrinus Pourtalesi, n. sp.

Smaller than either of the other described species. Th column is unknown, but, from the impression of its attachme to the lower excavated parts of the basal plates, it was evidentl more or less pentagonal.

Calyx low, about two thirds as wide as high, basal-cup subglobose, constricted and truncated above and deeply excavate below for the reception of the column. The portion compose of the first radials and anal plate, being a little less in diamete at its junction with the basals, expands upward and gives t the whole calyx a form somewhat urn-shaped.

Basal plates nearly uniform in size, two-thirds as wide a high, slightly widest above, strongly convex and bulging in th middle, being curved somewhat like the staves of a cask, uppe faces nearly truncate, lower faces truncated with abruptl rounded edges and excavated. They are heavy plates, soli below, leaving only a small perforation connecting with th column.

Radials, four. The first radials, alternately arranged wit the basals, are only one-third of their size, wider than long quadrangular, closely joined at the lateral sutures, and slightl set in from the outer upper edge of the basals, leaving a rathe deep transverse suture. Second and third radials as wide a the first and more than twice as wide as high. Fourth radial larger than the others, pentagonal, supporting upon their uppe sloping faces the free arms.

Arms comparatively robust, tapering rather rapidly to the ps. The arm joints are at their surface angularly elevated in e middle, depressed toward the sides, the sutures between em have at the middle angular part of each joint a strong ownward curvature, a peculiarity which is also observable in e radial series. The arms in this feature recall the charac- ristic structure of those of *Taxocrinus* and *Forbesiocrinus*. hroughout the greater portion of the arms, every alternate int is a syzigium, very obtusely pentagonal, twice as large as e other arm joints, and to the longer margin of each which is ightly angular, is attached a pinnule. The pinnules originate a very distinct articulating scar near the upper part of the ate. The intermediate plates are quadrangular in outline. rom the bifuricating radial to the second pinnule two quadran- ular joints are interposed between those to which the pinnules e attached. The great size of the syzygial joints, as compared ith the others, and their rather pentagonal shape, cause the innules to branch from the arms at a considerable angle, and lso give to the arms a marked waving form. The pinnules ring alternately from every second syzygial joint on either de of the arms, they are simple, composed of quadrangular ints, heavy, long, tapering but slightly, nearly all thus aintaining the same size throughout their entire length.

The ventral sides of the arms and pinnules are in our specien perfectly covered with alternating minute plates. The me arrangement of plates has been observed by us arching e ventral furrow in the arms of *Cyathocrinus*, *Poteriocrinus*, *ynbathocrinus*, and *Cupressocrinus*, and Messrs. Meek and Woren have observed it in the arms of *Batocrinus*. We are led believe that the ventral furrow was similarly arched in all aleozoic Crinoids.

The anal side and proboscis are hidden in our specimen and annot be described. The surface of the radials and arms is ndistinctly carinated.

B. Pourtalesi can be readily distinguished from any other nown species. From *B. florifer*, which it perhaps most nearly esembles, it differs in its more globose basal cup, its smaller rst radials and its wider free radials, which are fully twice as ide in that species, also in the proportionally shorter and eavier brachial pieces, the extreme size of the syzygial joints s compared with the intermediate ones, the robust and rapidly apering arms, in the angular form of the arm joints, the curving utures between them, and in the peculiar shape and crenulated pper part of the calyx of that species. From *B. Whitei* it iffers in its shorter, more globose and smaller cup and in the orm of the first radials. From *B. typus* in the same respects, nd also in the waving form and angular surface of the arms.

We take pleasure in dedicating this elegant species to Coun
L. F. de Pourtales, the eminent Zoologist of the Museum o
Comparative Zoology at Cambridge, Massachusetts, who firs
called attention to the relations of this genus to one of the type
of recent Crinoids.

Geological position and locality: from the lower part of th
Lower Burlington Limestone, Burlington, Iowa. Collection o
Frank Springer.

ART. XXIX.—*On Thorpe's and Bunsen's methods for the Est mation of Nitrogen in Nitrates*; by S. W. JOHNSON.—*Contribu tions from the Sheffield Laboratory of Yale College.* No. XLV

IN volume xxvi, pp. 541, 549, of the Journal of the Chemic
Society, as well as in his treatise on Quantitative Analysis, p. 9
Thorpe has described a method of estimating nitric acid, i
which this acid is reduced to ammonia by the use of slips o
zinc coated with precipitated copper, a reducing combinatio
first employed by Gladstone and Tribe. The experimental r
sults given by Thorpe in support of his method are such a
apparently establish its great exactness, while in simplicit
and ease of execution, it would seem to be quite superior t
the similar methods that have been previously proposed.

Having occasion to make some determinations of nitric aci
I tested Thorpe's method in five distinct trials with pure sodiu
and potassium nitrates. The directions given by Thorpe i
his Quantitative Chemical Analysis are as follows:

About 25–30 grams of thin sheet zinc are placed in a flask o
about 200 c. c. capacity, and covered with a moderately co
centrated and slightly warmed solution of copper sulphate. I
about ten minutes a thick spongy coating of copper will be d
posited on the zinc; the liquid is poured off the metals, whic
are now well washed with cold water and covered with abo
40–50 c. c. of pure water. Weigh out about 0·5 gram o
pure nitre into the flask connected with a condensing arrang
ment. The liquid is gradually heated and distilled for abo
an hour. The distillate is treated with platinum tetrachlorid

These directions were followed as closely as possible sa
that the distillate was received in a standard acid in order t
measure the ammonia volumetrically.

In the first experiment 0·5712 of sodium nitrate were em
ployed, containing 0·09408 of nitrogen. After distillation wa
concluded, the distillate contained 0·02947 of nitrogen. Think
ing that the zinc hydroxide resulting from reduction of th
nitrate might retain ammonia beyond the power of simple di

lation to remove, although Thorpe makes no such suggestion, added a quantity of newly fused, pure caustic potash, and ore water and distilled again.

This second distillation gave additional ammonia equal to 0227 of nitrogen.

The total nitrogen thus obtained was:

1st distillation, 0·02947
2d " 0·02275
0·05222 instead of 0·09408

Or a deficiency of 45 per cent.

In a second trial, 0·6689 grams of sodium nitrate were taken. ne conditions of reduction were as near as practicable the me as before, but on completing the first distillation the odor nitric oxide was plainly evident in the receiving vessel, and e amount of free acid in the latter was greater than at the tset, the standard acid, not only being not neutralized by nmonia coming from reduction, but made more acid by the action of nitric oxide upon the oxygen and water of the consing vessels.

In a third experiment with 0·4193 grams of pure potassium trate, 40 grams of cleansed zinc were covered with concentrated pper sulphate solution for fifteen minutes, the precipitated pper was washed with great care to avoid as much as possible taching it from the zinc. 40 c. c. of water and the nitrate ere added, the mixture heated very gradually and distilled nally with addition of more water, for one hour. The result was ke that of experiment 2.

A fourth trial resulted in the same increase of acid in the ceiver. In all these cases the copper was very loosely atched to the zinc, so that by mere washing much of it, and on oiling most of it separated.

I now referred to Gladstone's description of his method of eparing the zinc-copper couple, and made a fifth experiment, llowing his different directions as follows:

A weak solution of copper sulphate (1·5 per cent $CuSO_4$) as employed, and the zinc was let remain in it for some time ntil the color of the solution was very nearly discharged. ne distillation was then conducted as Thorpe directs.

0·5338 grm. KNO_3 containing 13·84 per cent N.
yielded 5·20 " N.
deficiency= 8·64 " N.

Thorpe mentions no difficulty in the application of his pross except in case of ammonium nitrate. With reference to s analysis he says, "the discordances appear to depend upon fferences in the strength of the solution and the amounts of zinc and copper taken. If the solution is too strong, nitrogen dioxide is evolved, and if the amount of zinc and copper be insufficient, the reduction is incomplete." It is evident that the process needs further study to define the conditions of its successful employment.

In contrast with the above results I instance three estimations of nitrogen made by Bunsen's method,[*] on the same sample of potassium nitrate and with aid of the same standard alkalimetrical solutions as were employed in the experiments just described. In Bunsen's method the reduction is effected in the cold, in presence of 250 or 300 c. c. of water and excess of caustic potash by zinc-iron couples, prepared by twisting together sheets of the two metals.

The time of reduction in the first trial was twelve, in the others thirty, hours. After these times, the ammonia was distilled into the standard acid. The results were as follows:

	1.	2.	3.	Theory.
Nitrate taken,	0·4593	0·3374	0·2651	
Nitrogen found,	13·29 p. c.	13·49 p. c.	13·25 p. c.	13·84

The results fall short, it is seen, from 0·35 to 0·60 per cent.

My acknowledgments are due to Mr. E. H. Jenkins, for assistance in these trials.

ART. XXX.—*Westfield during the Champlain Period;* by J. S. DILLER, of Westfield, Massachusetts.

WESTFIELD, Massachusetts, is nine miles west of Springfield, and six miles north of the Connecticut State line, in a valley cut off from the western part of the Connecticut valley by the Divide Range (the trap ridge extending south from Mount Tom). The village of Westfield is situated between Westfield River and Westfield Little River. These rivers flow eastward, across the valley, and, after uniting a mile east of the village, their waters pass through the Divide Range into the Connecticut River below Springfield.

The region contains three extensive plains. Hampton Plain, beginning near Hampden Ponds, four miles northeast of the village, extends south to the Westfield River. Avenue Plain extends, from the mountains west of Westfield, east between the two rivers to the village. Poverty Plain begins south of the rivers, and extends south by the Southwick Ponds into the Farmington valley. Stratified deposits in the northern part of the Hampton Plain, near Hampden Ponds, are 286 feet above mean sea-level. From this place the plain slopes south elve feet per mile to near the Catholic cemetery, and is there 9 feet above mean sea-level, or 104 feet above highest modern od-level at Westfield. A plain extending south from near sthampton toward the Hampden Ponds, slopes in the same rection. The divide between Northampton and Westfield crossed, west of Hampden Ponds, by a valley through which e old canal extends. The highest plain in this valley near outhampton is 256 feet above mean sea-level, and slopes

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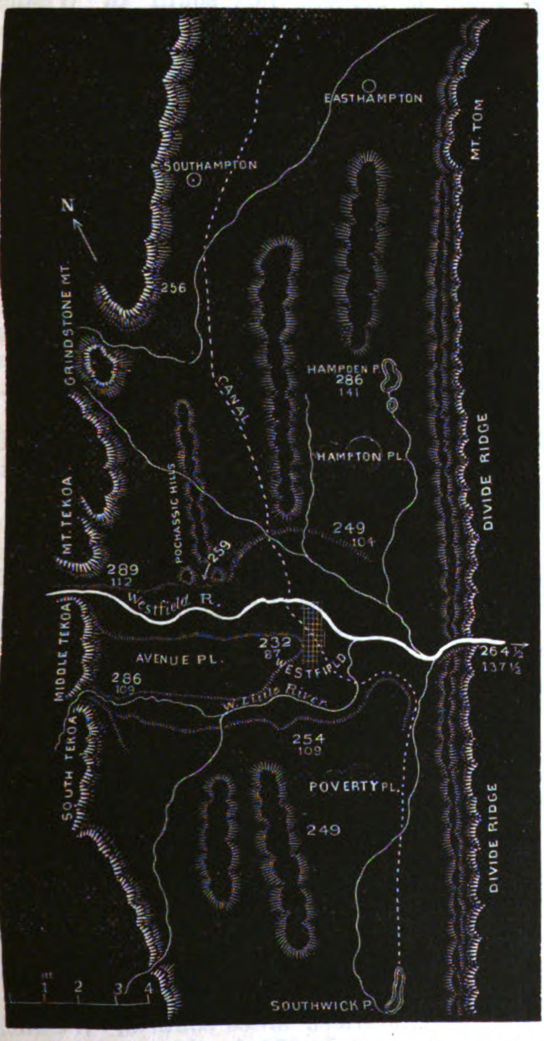
[*] Fresenius's Zeitschrift, x, p. 414.



toward the south. The northern part of the Hampton Plai is made of very coarse material, which gradually becomes fin toward the south. In the gravel of this plain, pebbles of tra are found.

Poverty Plain is highest just south of Westfield Litt River, where the stratified deposits are 254 feet above sea-lev (109 above flood-level at Westfield), and slopes toward the sout three and a third feet per mile. The material of the Povert Plain is finer than that of the Hampton Plain. Povert Plain is separated from Hampton Plain by the valley of t two rivers, and extends south into Farmington valley. T slope of these plains toward the south, and the grade in t material of the Hampton Plain in the same direction, are u mistakable evidences that during the period of their depositio the Champlain period, the water must have flowed over the plains from north to south.*

The appearance of trap pebbles in the Hampton Plain poin to the same conclusion. Not any trap rock is found in t basin of the Westfield River west of the Divide Range. Ham ton Plain is separated all along its eastern boundary from t Divide Range (trap) by a ridge of sandstone rising far abo the stratified drift of the plain. From these conditions it evident that the trap could not have been washed into t plain from either the east or west. Following the Divi Range to Mt. Tom, it will be seen that this mountain owes height to the westward advance of the trap and underlyi shale, making it to rest directly upon the hard conglomera which forms a separate ridge south of Mt. Tom. The talus of tr on the western side of Mt. Tom would be carried, by a strea flowing south, along the western base of the mountain, direct into the Hampton Plain. There seems to be no doubt t the pebbles of trap are from Mt. Tom, and were carried i their present position by a stream from the Connecticut Ri flowing south (as Professor Dana has already shown), west Mt. Tom, over the Hampton and Poverty Plains into t Farmington valley.

The highest stratified deposits in the vicinity of Westfi are near Mt. Tekoa, 289 feet above the sea, and 112 feet abo the flood-level of the Westfield River where it issues from t mountains. Hampton Plain, as already stated, rises 286 f above the sea. According to Professor Dana, there is a terr at Tariffville, Conn., fourteen miles south of Westfield, in t same valley, having a height 275 feet above sea-level. He taken this as proof that the height of the flood over the mid part of the Westfield basin was at least 275 feet. The heig

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* Professor J. D. Dana derived the same conclusion, this Journal, vol. x, I No., 1875, pages 504–507.

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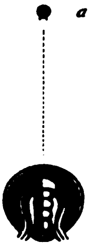

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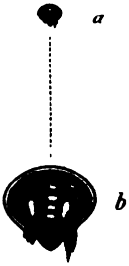

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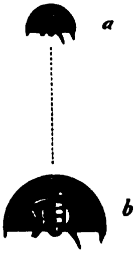

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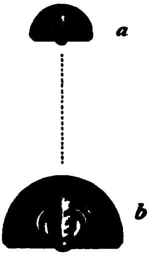

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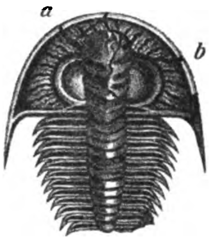

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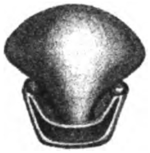

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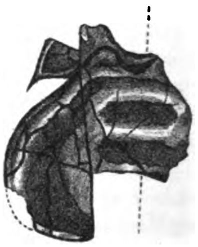

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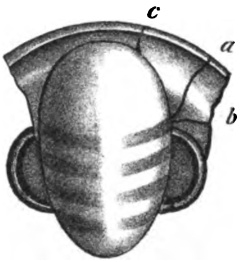

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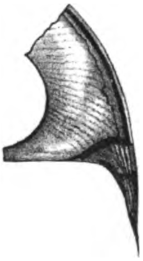

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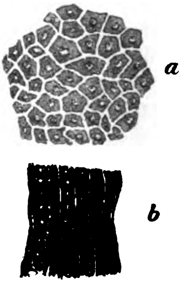

S. W. Ford del.

Mavrick & Wissinger, 138 Fulton St. N.Y.

ven above, one in the valley and the other, a greater height, pon its side, show, after making reasonable allowance for the ope of the water, that the level of the highest flood was at ast 280 feet above mean sea-level.

During the greatest flood, the Westfield River and the West- eld Little River, joining the waters from the Connecticut, owed south over the Poverty Plain into the Farmington lley. The lower deposits in this vicinity were made by the estfield Rivers before the overflow from the Connecticut egan. One of the first results of the overflow from the north ust have been to fill the former valley of the Westfield Rivers, that during the time of greatest flood the Hampton and overty Plains must have been one continuous plain.

The north end of the Poverty Plain is five feet higher an the south end of the Hampton Plain, and while the latter opes twelve feet per mile the former slopes only three and a ird feet per mile. The material of the Poverty Plain is ner than that of the Hampton Plain. The differences in eight, slope, and material, are all due to the confluence of the ree streams upon the Poverty Plain, and to the damming the water by the Southwick Divide.

The Avenue Plain, at its western extremity, reaches its eatest height, 286 feet above mean sea-level and 109 feet ove flood-level of the Westfield River, at Mt. Tekoa. From is place it slopes east sixteen feet per mile to the village metery, where its height is 232 feet and 87 feet above flood- vel of the Westfield River at Westfield. The east end of the venue Plain is at least seventeen feet lower than the adjacent ds of the Hampton and Poverty Plains, showing that seven- en feet of stratified deposits must have been swept off the st end of Avenue Plain.

When the flood subsided, the overflow from the north ceased, d the Westfield rivers began to flow once more through the ivide Range into the Connecticut. By their conjoined action ey eroded the Avenue Plain to its present level, and cut for emselves, across the once continuous plain, deep valleys, ith the terraced sides that now appear.

RT. XXX.—*On some Embryonic Forms of Trilobites from the Primordial Rocks at Troy, N. Y.;* by S. W. Ford. With Plate IV.

THE existence, in the case of a number of species of Bohe- ian Trilobites, of a series of forms showing that, before reach- g maturity, the animal passed through several widely distinct ases of growth, is a fact long ago made familiar to geologists

by the researches of M. Barrande. In one instance, that
Sao hirsuta, he has shown that twenty such phases are passe
through, the earliest and simplest forms being of almost micr
scopic minuteness and presenting scarcely any resemblance
the individual when completely developed. These phenomen
have been styled by Barrande the "Metamorphoses of Tril
bites;" and in his truly magnificent work on the Trilobites
Bohemia (Systême Silurien de la Bohême, vol. i, 1852,) the
are fully and ably set forth and discussed. Hitherto, howeve
no example of a truly embryonic form of trilobite, or one sho
ing that the animal was mainly developed after quitting th
egg, has been found in other than Bohemian strata; a fa
which, when we consider the prodigious numbers of these an
mals that existed in Paleozoic times, the care with which th
rocks in which they occur have been explored in many cou
tries, and the profound study which their remains have receive
at the hands of many distinguished investigators, would seem
indicate that, in the greater number of species, no such form
ever existed. I beg leave to submit herewith the evidence
have obtained of the metamorphoses of an American trilobit
the species being the *Olenellus* (*Elliptocephalus*) *asaphoides*
Emmons. I shall discuss this evidence, together with certa
other material which I possess pertaining to this species, und
the following heads:

Genus OLENELLUS Hall.

OLENELLUS (ELLIPTOCEPHALUS) ASAPHOIDES Emm.

I. *Embryonic Forms.*

In the spring of 1868 I discovered several specimens of th
species in the limestone beds at Troy, showing clearly th
characters of *Olenellus*, which were afterward fully identifie
with the Washington County form by Mr. Billings. Sin
that time I have added to my list of specimens whenev
opportunity has offered. Although some of the specime
obtained early in the course of my investigations appeared
me somewhat rudimentary in character, yet it is only of lat
and after laboriously working away the partially envelopi
rock, that I have become fully aware of the real richness
the material. Further researches will doubtless supply mu
that is still desirable.

Fig. 1*a* represents, natural size, the earliest stage of grow
observed, and 1*b* the same enlarged five diameters. The spe
men is nearly circular, one line in greatest width and lengt
with a wide concave border which, toward the edge, is be
upward so as to form a neat marginal rim. The glabella
three-fifths the total length. It is divided into five distin
lobes by four well defined furrows extending all across. T

rward lobe is considerably larger and spreads out laterally
eyond the others, which are of nearly equal shape and dimen-
ons. It stands out prominently in the specimen. The eye-
bes are of an elongate semi-lunate form, and, springing from
ie postero-lateral angles of the forward lobes of the glabella,
xtend backward nearly as far as the last glabellar furrow. At
ie posterior extremity of each and in direct continuity with
iem is a well-defined rounded ridge which extends outward
nd backward toward the postero-lateral margin, with the raised
lge of which it unites to form a slender spine. The spaces
etween the eye-lobes and glabella are tumid and are prolonged
ackward as two spines lying within the former. These I shall,
r convenience, call the "inter-ocular" spines. I have no doubt
ut that all of these spines terminate in acute points, as they
e all seen to taper slightly in the specimen; but as they pass
eneath the stone a short distance from the disk, I have
iought it better not to run the risk of destroying them
together in attempting to further develop them. Between
ie two spines last described lie the last glabellar lobe and its
ppendage, the latter a simple, smooth, narrow, nearly flat or
nly feebly convex plate, convex in outline behind, and giving
the specimen its nearly circular form. This plate I consider
be a rudimentary pygidium. I believe this to be one of the
iost rudimentary trilobitic forms ever discovered. At present
appears to me to be equally humble in structure with the
rm representing the first stage of growth of *Sao hirsuta* illus-
ated by Barrande. The head is greatly predominant. There
no thorax, and no pygidium properly so called.

With regard to the nature of the spines and ridges which I
ave just described I became greatly puzzled as my study of
ie specimen continued. At first I was disposed to look upon
iem as simply ornamental in their nature, regarding the ridge
hich runs backward from the eye-lobe as simply the eye-lobe
self fancifully prolonged. Afterward, however, I was led to
ke the *economy* of the animal organization into account, and
om the moment of doing this I was conducted to very differ-
nt conclusions from those first entertained. I believe the
uter spine of this individual to represent the permanent spine
f the genal angle in the adult, and the little ridge which
ins backward from the eye-lobe to this spine and helps to
rm it to represent that portion of the posterior margin of
dults which lies between the genal angle and the facial suture.
he inter-ocular spines I am inclined to regard at present
s having been most probably protective in their office. Be-
ween the ridges extending from the eye-lobes and these spines
iere is an open space or *slit* in the shield. This space repre-
ents, I believe, the position of the posterior portion of the

facial suture in the adult. At this stage that portion of the posterior margin of adults which lies within the sutures is not even indicated. The specimen presenting these remarkable features of structure is in a beautiful state of preservation.

Fig. 2*a* represents another specimen, natural size, and 2*b* the same enlarged three and one half diameters. The lower left hand portion of the border is slightly restored in each. This specimen is, in extreme width, two-thirds larger than the first example, and in extreme length, exclusive of the spines, one-half larger. The form has changed considerably, but it requires but a moment's attention to convince one that the fundamental structure is, in all respects, the same with that of the preceding example. The shield is more spread out laterally, and markedly so at the mid-length; the eye-lobes in their forward portions are more arched; the glabella is more acutely and regularly tapering; and the proportional distance between the inter-ocular spines at their origin is considerably increased. The glabella is marked by four distinct furrows extending all across as before. Immediately in advance of the fourth or foremost furrow there is a slight ridge extending all across the anterior lobe, which gives to the eye-lobes the appearance of meeting on the median line of the glabella. The neck-furrow is strongly marked. On either side of the neck-segment is a short, deep, longitudinal furrow with an elevated rim bounding it behind. We have here rudely sketched out that portion of the posterior margin of adults which lies inside of the sutures. In contact with this margin there is a somewhat convex, triangular body, the central portion of which is damaged, but which shows on each side two or three obscure furrows extending outward and backward. This body, both from what Barrande has taught respecting the mode of development of the thorax of trilobites and from the appearances themselves, I consider to be most probably a rudimentary thorax and pygidium combined. From the even manner in which it is outlined it is probable that none of the segments were yet free. The surface of both this and the foregoing specimen is smooth.

Now, if we examine the figures it will appear evident, I think, that, between 1 and 2, one or more intermediate forms may exist, and between 2 and 3 a considerable number of such forms. As yet, however, no such forms have been obtained. Figure 3*a* shows, natural size, and 3*b* twice enlarged, a head whose development is evidently nearly completed, but which is, nevertheless, embryonic in certain of its features. There still exist the strong inter-ocular spines and the glabellar ridge uniting the eye-lobes in front. The glabellar furrows also extend all across, but become fainter on the median line. The eye-lobes are rather more regularly curved than represented in the figure.

In this specimen we have the first indication of the fine system of surface lines which ornaments so beautifully, in many instances, the adults. From the posterior extremity of the eye-lobe there is a slender though distinct ridge running backward parallel with the inter-ocular spine, lying close alongside, to the marginal edge and forming with it a continuous elevation. Between this little ridge and its adjacent spine is the place of the suture. In this, as in the preceding example, the inner formed portions of the posterior margin wall against the inter-ocular spines. These spines are here clearly seen to lie *in* the marginal border, or rather between its still disunited outer and inner portions, appearing as if occupying a little notch in that border especially intended for their reception. The spines of the posterior angles are only partially preserved.

In figure 4*a*, which is of the natural size, and *b* the same enlarged as before, the posterior margin is continuous or united at the sutures; but there is a little ridge running from the base of the eye-lobe to the marginal edge, as in the preceding case. This character is likewise shown in all perfect adult specimens. The specimen is perfect excepting the posterior spines. The characters are all only those of adult growth. There are three pairs of glabellar furrows in advance of the neck-furrow, none of which reach the median line, and in addition, as is likewise true of most adult specimens, a short, fainter fourth pair in front of the anterior extremities of the eye-lobes. The neck-furrow is continuous all across. The spaces between the eye-lobes and glabella are but moderately convex and were no longer provided with spinous appendages. The surface of the cheeks is ornamented with exceedingly fine waved lines, best shown in the concavity just within the marginal rim.

I have purposely dealt with figure 4, under this head, in order to prepare the way for a better understanding of certain features of structure presented by the embryonic forms to which I wish more particularly to refer. Returning to figure 3*a*:—on comparing this form with 2*a*, we observe the principal differences to consist in the relatively greater lateral expansion of the postero-lateral portions of the shield in the former, these being extended so as to give to the form a nearly semicircular outline; the relatively smaller size of the tumid spaces between the eye-lobes and glabella; the relatively nearer approach of the posterior portions of the eye-lobes to the glabella; and in the presence of a nearly perfectly formed, though not, as yet, united posterior border. With the completion of the perfect union of the posterior margin at the sutures, the inter-ocular spines appear to have been no longer of use and were altogether suppressed. Figure 4 is an example of this. But in all essential features of structure I believe 2 and 3 to be fundamentally the same. If, in the case of figure 2 we were to suppose that portion of the ridge running from the lower extremity of the eye-lobe which does not enter into the composition of the spine of the general angle to be elastic, and then draw the lower end of the eye-lobe downward and inward as close to the glabella as possible, at the same time carrying the genal angle outward a little way, we should get a short horizontal posterior margin between the outer and inner spines. This is similar to what, I believe, has, in effect, actually occurred in the growth and development of this form, the growth being both inward or toward the line of suture and outward or toward the angle, giving us a form such as we observe in figure 3. I have no doubt but that future discoveries will bring to light forms illustrating this, and also showing us more fully the various stages of unfolding passed through in the development of this extraordinary species of trilobite.

II. *Adult Forms.*

Fig. 5 represents, twice enlarged, an unusually perfect specimen. It is of a young individual, but the characters show that it was, without doubt, a fully developed form. The head is somewhat crushed and fractured, but the main features are beautifully shown. The thorax is incomplete, and the pygidium is wanting. There are twelve pairs of ribs preserved. These decrease in length in a regular manner, constituting an exceptional feature in the structure of the genus.* In one of the three specimens of this species figured in Dr. Emmons' works there are fourteen articulations in the thorax, but it is impossible to say whether this is the total number possessed by the individual. His figure also shows one of the posterior spines of the head in place with its characteristic surface-markings.† In our specimen the whole surface of the head beyond the eye-lobes and glabella is covered with irregularly alternating finer and coarser lines radiating outward to the margin. These lines are somewhat too coarsely represented in the figure, but it shows well the peculiar character of the ornamentation. In this specimen the slender ridges running from the eye-lobes to the posterior margin along the sutural lines are very apparent. The eye-lobes are not actually in contact with the glabella behind as shown in the figure, which would also slightly change the direction of the ridges extending from them. At *a* and *b* the shield is fractured, but I do not consider either fracture as coincident with the course of the suture. In fig. 8, which represents the glabella, eye-lobes, and portions of the cheeks of a large individual, the whole considerably weathered, there are three such fractures. Of these *a* coincides very nearly in relative position and direction with *a* in fig. 5. But this coincidence appears to me to be only accidental. It is possible, judging from a specimen in my collection showing the under side of the head with the hypostoma in place, that the line *c* coincides with the suture, but I do not feel at all satisfied of this. I have never been able to ascertain to my entire satisfaction the direction of the suture in front of the eye in any specimen. The shield appears to have fractured as easily in one direction as another. This would seem to indicate that the cheeks were very firmly united at the sutures in front. This, if true, has an important bearing upon what I have stated in regard to the mode of formation of the posterior border in the embryonic stages; for if, according to my view, the posterior portions of the sutures were, almost from first to last in the progress of the metamorphoses, only *indicated* by the structure, the spaces in the developing margin which they were to occupy being long left open, we can readily understand why the anterior portions of the shield should have been firmly held together. The changes that took place in the forward portion of the shield during the period of development were, as compared with those in the backward, relatively unimportant both as to kind and amount.

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* See Barrande,—"Documents anciens et nouveaux sur la faune primordiale et le Système Taconique en Amerique." Bul. Geol. Soc. France, 2 Ser., vol. xviii, p. 203, 1861. Also, the writer, "Note on *Microdiscus speciosus*," this Journ., Feb., 1877, p. 141.

† "American Geology," pl. 1, fig. 18, 1855. See also "Taconic System," pamph., 4to, p. 21, 1844.

This species sometimes attained an enormous size. One specimen of the glabella in my collection is an inch in width at its narrowest part. The surface of the head in some cases presents an exceedingly ornate appearance. Occasionally the whole surface of the cheeks is covered with small polygonal areas having a little prominence in the center of each, these areas being formed by the irregular interlacing of the fine raised surface lines. In other cases this arrangement holds good for the more central portions of the cheeks, while toward the margin the lines become more regular in direction and better defined, and sometimes become so widely separated as to enclose two or more rows of what were before the little tubercles or prominences in the polygonal spaces. Figs. 10*a*–*b* are intended to illustrate what is here meant, *b* being a small segment of the outer portion of a cheek greatly enlarged, and *a* an enlargement of one of the inner portions. At other times the whole surface of the cheeks is covered with tubercles with no enclosing lines, and at still others with only irregular lines with no tubercles.

Fig. 9 is of a portion of one of the cheeks preserving its spine. The upper crust is nearly all removed, but at the spine we see it present with its usual ornamentation. The specimen is, for the most part, a cast in stone of the outer or lower surface of the "doublure," which is shown to be ornamented in much the same way as the upper surface of the shield. Along the outer edge there is a portion of the doublure itself remaining.

III. *The Hypostoma and Epistoma.*

Of the hypostoma of this species I have several specimens, one of which, a very perfect example, is here figured twice the natural size (fig. 6). Its form and structure both show it to be very closely related to the hypostoma of *Paradoxides*. The surface is smooth. The central body is exceedingly convex. In his description of the type of the genus, *O. Thompsoni* (13th Regents' Rep. and elsewhere), Professor Hall says of the hypostoma that it is "broadly ovate, little longer than wide." As this description was too imperfect to be made available in comparison, and was unaccompanied by a figure, we were thus left in doubt regarding the testimony of this, one of the most important parts of trilobites that can be employed in the identification or differentiation of genera. In the form of the hypostoma, the shape of the glabella, and in its *facies*, this genus is evidently closely related to *Paradoxides*, more closely I believe than to *Olenus*, as was originally believed by most paleontologists who investigated it. The glabella in all the species is widest at the frontal lobe. In the case of *O. asaphoides* we see that this is a feature that is early marked out in the structure.

In a small number of species of trilobites described and figured by Barrande, there is shown to exist a second plate quite similar in shape to the hypostoma, but placed in the interior of the cephalic shield. This he has called the "epistoma." We have not hitherto found this organ in any American trilobite. About three years ago I obtained an enormous glabella of *O. asaphoides*, beneath which there appeared to be at one point indications of the existence of a plate of different character from anything I had previously seen. The specimen remained in my hands in this state for a long time, but I finally succeeded in developing the body referred to, which is the remarkable form represented (nat. size) in fig. 7 of the plate. It shows a central or sub-central elevated area with two deep oblong parallel furrows; an elevated left-hand border, and between these a wide concavity. At the upper left-hand portion is the cast of a stout spine. Just to the right of this a portion of the plate has been removed. The surface presents a smooth polished appearance. This plate I believe to be the epistoma of this species.

The specimen whence this plate was obtained consisted as originally discovered of two parts, one showing the inner surface of the crust of the glabella, and the other its impression in limestone. Beneath this latter, at about a line's depth, was shown a portion of the plate in question. At present the specimen consists of three parts, or rather four: (1) The inner surface of the glabella; (2) a limestone cast of the same; (3) the epistoma attached to the lower side of No. 2; (4) a cast of the lower or mouthward side of the epistoma, and preserving its spine. The layer holding the epistoma came away in several pieces. These have been glued together, and the relations of the parts of all four of the pieces can be made out with ease and certainty.

As will be seen from the figure, the plate is in a fragmentary condition. Compared with the hypostoma it is probably represented in an inverted position in the drawing. The upper portion in the figure is probably the backward portion in the specimen. This is, moreover, its position beneath the glabella. It lies diagonally across the latter, with its spinous portion resting directly beneath the neck-segment. It has doubtless become detached and slipped backward. It appears to me probable that the straight dotted line in the figure indicates approximately the middle line of the perfect specimen. This is all that I desire to say upon the subject at present.

To sum up: I believe the facts which have been presented prove conclusively that we have in *Olenellus asaphoides* an example of the metamorphoses of trilobites, and clear up some points that have always been in doubt concerning the genus, besides affording us a more complete life-history than we have hitherto possessed of any trilobite from American strata. In my investigation of this singular life-history I have striven earnestly to read the record aright. How far I have succeeded in this must remain for my fellow laborers in the department to determine.

All of the specimens described and figured in this paper were collected by the writer from the limestone beds of the Lower Potsdam Group at Troy, N. Y.

New York, February, 1877.

ART. XXXI.—*The Winds of the Globe; or the Laws of Atmospheric Circulation over the surface of the Earth*; by JAMES H. COFFIN, LL.D., Professor of Mathematics and Astronomy in Lafayette College.*

THIS volume, to which the author devoted many years of earnest labor, may be considered, as its title implies, an extension of his earlier treatise on the Winds of the Northern Hemisphere. Its design is to show

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* *The Winds of the Globe; or the Laws of Atmospheric Circulation over the surface of the Earth*; by JAMES H. COFFIN, LL.D., Professor of Mathematics and Astronomy in Lafayette College. xxvi and 756 pp. 4to, with 26 plates. Washington, 1876. Completed, on the author's decease, by Professor Selden J. Coffin, Ph.D.; with a discussion and Analysis by Dr. Alexander Woeikof.—Smithsonian Contributions to Knowledge.

1st. The mean direction of the wind in all parts of the earth.

2d. The ratio that the progressive motion bears to the total distance traveled.

3d. The modifications that the mean current undergoes in the different seasons of the year.

4th. The directions in which the forces act that produce these modifications.

5th. The amount of their intensities.

6th. To show, by separate solutions for the surface winds and those indicated by the motion of the clouds, how the two differ, and how they differ according as we do, or do not, take into account the difference in the velocity of the different winds.

The data used for elucidating these points consist of series of observations on winds made at 3,223 different stations on land, and during numerous voyages at sea, extending from the parallel of 83° 16′ north latitude, to beyond the parallel of 75° south latitude, the extreme points ever reached by man, altogether embracing an aggregate period of over 18,500 years. If the area between latitude 60° N. and 60° S., where observations are more abundant, be divided into geographical squares, by drawing meridians and parallels of latitude 5° apart, of the 1728 squares so formed 1410 are represented in this work. The 318 vacant squares, from which no observations have been obtained, are as follows: Twenty-one in North America, mostly in British America; forty in the interior of South America; none in Europe; seventy in Central Asia; sixty-three in Africa; fifteen in the interior of Australia; one hundred and eight in the North Pacific Ocean; and one in the South Pacific Ocean.

It seems eminently desirable that the great paucity in the North Pacific Ocean, should be filled; particularly as it is supposed that the material for doing so exists, though entirely unreduced, among the archives of the United States Naval Department.

To facilitate condensation in the results, the stations that reported directly to the Smithsonian Institution have been grouped into convenient districts, about 100 miles square, and the total number of observations has been given for at least eight points of the compass, during each of the four seasons. In the case of most other stations, and particularly when the series extended through a long period of years, the total number of observations is given for each month of the year, and to sixteen points of the compass. By this summary the distinctive features of the system of winds in any part of the earth are not obliterated by condensation, excepting, of course, when those of a particular epoch are sought, as in the case of the investigation of storms. For this the present work is not available; although the author appreciated this end, as shown in his preparation of a previous work,* in which 300 pages are devoted to selected records from 400 localities in the United States, extending through several days each, in the case of storms that occurred in March and September, 1859, and noting not only the winds, but all the accompanying meteorological phenomena.

The method of summing and presenting this mass of material, is by five series: in each of which the separate seasons and points of the compass are kept distinct, viz:

I. The number of observations.

II. The number of miles traveled, as estimated by the observers.

III. The mean velocity in miles per hour.

IV. The number of observations taken on the upper current, as indicated by the motion of the clouds.

V. A velocity table computed from the first three series, the results of which will be noted farther on.

In series I, II and IV, the trigonometrical resultants are computed, both as to direction and the ratio of the resultant to the sum of the winds. Of these the work embraces 16,000 solutions, about one-half of which find place on the charts. The deflecting forces have been wrought out in about 8,000 of these instances.

The peculiarity of series V may be seen in an example. Certain stations in New Hampshire, north of latitude 40°, during the years 1854 to 1857 inclusive, give the following result:

	Spring.	Summer.	Autumn.	Winter.	Year.
Average velocity of all winds in miles, per hour,	8·16	6·39	6·48	8·91	7·48
Velocity in mean direction, on the supposition that the winds from every point of the compass move with the foregoing velocity,	2·72	1·67	2·77	3·82	2·66
True velocity in mean direction, giving to the winds from every point of the compass each their own average velocity, as shown in the table above,	2·91	1·80	2·70	4·48	2·88
Excess of the latter over the former.	+·19	+·13	−·07	+·66	+·22

Let the movement of a particle of air be traced, which is supposed to be stirred only by the winds that are found day after day at a given place: at the end of the year the path of the particle, though entirely irregular, will—so far as its progress and general direction are concerned—be essentially the same as the curve more easily formed by joining the four lines, whose direction and length are recorded in the resultants of series I. On the North American coast of the Atlantic the curve is of this general shape ⌣⌢, while on the European coast the curvature is reversed, being ⌢⌣. The change seems to occur in mid-ocean at longitude 30° to 35° west. Except where there are marked local obstructions to the free flow of the air, this law seems invariable; and it holds in the majority of cases, even in the motion of the clouds; but Mount Washington, New Hampshire, seems a remarkable exception; the observations for 1870–3 give as resultants—

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* Results of Meteorological Observations, 1854–59. Vol. II, Part 1.—United States Senate Document, 36th Congress.

	Resultants.	Ratio.	Monsoon influence.	
Spring,	N. 87° 21′ W.	·62	S. 17° 15′ W.	·13½
Summer,	N. 62° 33′ W.	·62	N. 12° 30′ E.	·13
Autumn,	N. 60° 46′ W.	·63½	N. 9° 3′ E.	·15½
Winter,	N. 87° 38′ W.	·60	S. 9° 1′ W.	·13⅓

These S-shaped curves were pointed out and illustrated by Professor Coffin, in 1848, at the same time that he announced the existence of the Polar system of the northeast winds, and the Temperate system of the westerly winds. The forces that deflect the wind from its mean annual direction, and so cause these peculiar curves are given under the title of Monsoon Influences. Are they due to changes in the temperature, or to variations in atmospheric pressure at the different seasons? An examination of the maps shows instantly that in all parts of the globe, these deflecting forces are inclined toward the nearest adjacent land-center in the summer, and toward the center of the nearest large body of water in the winter, thus showing the direct agency of heat in modifying the direction of the current, and the intensity of its flow. That barometric pressure however plays the more important part in effecting these seasonal changes of direction is shown in Dr. Woeikof's minute discussion; wherein, reproducing the isobaric charts of Dr. Alexander Buchan, he considers the five wind systems in general, and then treats separately the winds in the smaller geographical divisions of the earth. He corrects the error, so generally prevalent, of limiting the monsoons to the tropical part of Asia, showing that they extend as well to all China, Japan, Mantchooria, the western coast of the Sea of Ochotsk, and the basin of the Amoor river; and, with a reverse of seasons, to Australia.

The winds on the whole Atlantic coast of the United States were early shown by Professor Coffin to possess some monsoon features, though slight. The influence of the Gulf of Mexico over the basin of the Mississippi and Ohio, from latitude 34° to 42°, in producing the west-southwest direction of the winds at all seasons, is traced to the constant maximum pressure existing to the south and the minimum to the north and northeast.

Dr. Woeikof instances latitude 40° to 60° south as that part of the earth where the winds have the greatest velocity, strong westerly winds prevailing there the whole year: due to the great difference in the pressure of the air at a small distance, or in other words, the steep barometric gradient. As to this topic, Professor Coffin left on record but a few general conclusions, of which we would note only his determination of 65° as the average angle made by the line of the wind's approach, with one drawn to the point of maximum pressure.

The velocity tables, elaborately prepared, mainly from data in the United States, are designed to show the effect of combining the element of velocity with that of time, in computing the resultants. The question is one of vital importance, and the magnitude of the task alone hinders its being solved in a similar manner for all parts of the world. Five years of working time were spent on the reduction of the observations taken at 418 places on the American continent, for a total period of 700 years. The results show that the effect of velocity is to throw the resultant northerly far more frequently than southerly, and at a much greater angle; that it increases its magnitude far more frequently than it diminishes it, and by a greater amount.

In the United States, north of latitude 32°, the annual results obtained by noting the actual velocities average S. 89°+W., with a ratio of ·261; while those had by disregarding the unequal velocities are S. 80°+W., ratio ·227. The divergence is therefore about 9° in the yearly resultants, but greater in winter, and less in summer.

This general fact of a [northerly] divergence and excess of ratio, holds true also for the few places computed, that are situated within the limits of the Polar and Equatorial systems; yet, as the divergence seldom exceeds 15°, the great general conclusions reached must be considered safe, although the variation in velocity be disregarded.

The average velocity, so obtained, of all winds in the United States, is seven miles an hour, being slightly in excess in the northeastern part of the Union, and less in the States nearer the center of the continent.

For positions considered separately, the velocity of the wind is greater—

1. On high isolated peaks, than at low stations,
2. On the seashore, and especially on isolated islands, than in the interior of continents,
3. In level countries, than in countries surrounded by mountains; and
4. In prairies, and especially desert countries, than in wooded regions.

A less velocity than the average belongs to the winds of the equatorial calm-belt, the calm-belts at the polar limits of the trade-winds, and the trade-wind belts.

There is an extensive region in the southwest of the United States, which has a common yearly period of winds, different as are its geographical features. It includes the extreme southeast of California, Arizona, New Mexico, Southern Utah, Texas, Arkansas, the Indian Territory, Eastern Colorado, Eastern Wyoming, Southern Dakota, Nebraska, Iowa, Kansas, and Missouri. The winds are southeast, south, or southwest in summer, with a great ratio of the resultant in the south, diminishing toward the north and east. In winter the winds are mostly north and northwest. This region is equal to more than a million square miles, or about one-third of the United States, without Alaska.

A comparison of the motions of clouds with the mean direction of the surface current, shows that they very nearly coincide in nearly all regions of the United States; the former being more purely west, and having a ratio of resultant of 42 per cent—nearly double that of the surface current, which is 23 per cent—thus showing a steadiness of motion admitting of little monsoon influence; while the lower current has a more west-southwest direction between the Mississippi and the Appalachian chain, and a west-northwest direction in New England.

As the northern and southern boundaries of the great westerly current are approached—at least in the United States—the length of the arrows that designate the cloud current decreases as much below the 42 per cent above named, as they surpass that figure in the center of the aerial stream; and thus the southern limit of this system of cloud motion seems to extend down to north latitude 30°, some three degrees farther south than is assigned to the corresponding system of surface winds.

The work is rich in tabular matter, especially from Spain, Norway, Russia, Siberia and India. Twenty-six charts are attached, in which the general features of the wind systems are delineated, mainly by resultants and wind-roses; the latter bringing into contrast the summer and winter winds. Horary, monthly and annual variation is traced; and one chart exhibits the connection of the wind with fluctuations in the thermometer, amount of cloudiness, and fall of rain and snow. The whole forms a valuable summary of facts in this department of meteorology.

ART. XXXII.—*On some Nitro-derivatives of Diphenylamine;* by Dr. PETER TOWNSEND AUSTEN.

A PRELIMINARY notice of the following investigation was published in the Berichte der Deut. Chem. Ges., vol. vii, p. 1248. I had hoped, long before this, to have completed the research in a more satisfactory manner, but my time having been occupied with other subjects, I have but recently been able to return to it.

Pisani[*] found that trinitrochlorbenzol acted on ammonia, and formed trinitroaniline. Clemm[†] applied this reaction to aniline, and obtained a trinitrodiphenylamine. In a similar manner he produced a dinitrodiphenylamine by the action of dinitrobrombenzol on aniline.

The reaction in all of these cases is simple—

$C^6H^2(NO^2)^3Cl$[‡]$+2NH^3=C^6H^2(NO^2)^3NH^2+NH^4Cl$

Several nitro-derivatives of diphenylamine had already been discovered by Hofmann[§] before the research of Clemm was made. They had, however, not been produced by the introduction of a nitrophenyl-complex into aniline, but by the direct nitrition of benzoyldiphenylamine, and subsequent elimination of the benzoyl-group.

The trinitrochlorbenzol was made by Clemm's method; 100 grams of picric acid were well mixed with 200 grams of phosphorous pentachloride, and placed in a large retort connected with an inclined condenser. On heating gently, the mass began to fuse, on which the burner was taken away. The reaction proceeds by itself and is very violent. After the cessation of the action, most of the phosphorous oxychloride was distilled off. The heavy red liquid, remaining in the retort, was poured into a large excess of cold water and violently stirred. After the phosphorous oxychloride had been entirely decomposed by the water, and the mass had solidified, the impure substance was well washed with water, powdered, and extracted with ether by means of a filter pump. A dark-red resin was by this means removed. The bright yellow powder, left on the filter, was dissolved in boiling absolute alcohol and purified by animal charcoal.

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[*] Ann. Chem. Pharm., xcii, 326.

[†] Jour. Pr. Chem. [II], i, 145.

[‡] On the ease of substitution of haloid atoms in nitro-compounds, see my Einleitung zu den aromatischen Nitroverbindungen, page 8. "Chlorbenzol lässt beim Behandeln mit alkoholischem Ammoniak unter keinen Umständen sein Chloratom durch die Amidogruppe substituiren. Chlormononitrobenzol aber bei erhöhter Temperatur; Chlordinitrobenzol bei 100°; während Chlortrinitrobenzol schon in der Kälte energisch auf Ammoniak wirkt. Aus diesen, wie aus zahlreichen andern ähnlichen Thatsachen, ziehen wir die Schlussfolgerung, dass die Nitrogruppe die Anziehung der andern negativen Atome lockert. (Vergleiche auch Salkowski (Ber. Chem. Ges., vi, 141), Engelhardt und Latschinoff (Zeit. Chem., 1870, 225), Walker und Zincke (Ber. Chem. Ges., v, 114).)"

"Umgekehrt dürfen wir voraussetzen, dass dieselbe die Anziehung der positiven Gruppen des Moleküls verstärken müsse. Dass diese Voraussetzung richtig ist, geht aus dem Verhalten der Amidogruppe hervor. Behandelt man Anilin mit Amylnitrit, so ist die Einwirkung sehr heftig, bei Nitroanilin weniger, bei Dinitroanilin sehr ruhig, während Trinitroanilin keine Reaction giebt." According to Körner (Jahresbericht, 1875, 365), however, the weakening action of the nitro-group on halogens is only exerted when the relation is 1·2 or 1·4, not extending, however, to 1·3.

[§] Ann. Chem. Pharm., cxxxii, 160.

In this manner beautiful bright yellow crystals of trinitrochlorbenzol were obtained. By drying they became darker. The yield is from 30–40 per cent.

I obtained better results, however, by simply heating the substances in a high beaker glass, for I found that a considerable amount of the chlorpicryl was destroyed during the distillation of the phosphorous oxychloride. I found, also, that the yield was far better, when instead of 100 grams of picric acid and 200 grams of phosphorous pentachloride, 50 grams of picric acid and 100 grams of phosphorous pentachloride were taken. By this method the conversion of the picric acid into chlorpicryl, the decomposition of the phosphorous oxychloride, the extraction with ether, and the crystallization from alcohol, all together do not take more than an hour.

The trinitrochlorbenzol fused at 82·5°–83°. By dissolving it in glacial acetic acid, diluting the solution with water, and allowing it to stand, superb feathers, frequently over two inches in length, were obtained.

*Alphatrinitrophenylmetanitraniline.**

Preparation.—25 grams of metanitraniline (112°) and 27 grams of chlorpicryl were dissolved in boiling absolute alcohol. On boiling the solution for a few minutes, the separation of a heavy yellow crystalline sand began. This sand was not redissolved by addition of more alcohol. The solution was allowed to cool, the precipitate separated by filtration, purified by crystallization from glacial acetic acid, dried at 100°, and analyzed.

Analysis.—A combustion† gave—

0·2744 grms. of substance burned with lead chromate gave 0·414 grms. of CO^2 and 0·582 grms. of H^2O.

0·2752 grms. of substance gave V=48·8 c.c. [B=764·8 mm.; *t*=21·5°].

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* The trinitrophenyl-complex of picric acid is in this research distinguished by the prefix *alpha*. The relation is most probably para, but it requires experimental demonstration. (Compare Gnehm. Inaug. Diss.)

† The large number of nitro-groups present in these compounds rendered the use of an unusual amount of copper spirals necessary.

The formula $N\left\{\begin{array}{l}C^6H^4(NO^2)_m\\ C^6H^2(NO^2)^3{}_a=C^{12}H^7N^5O^8\\ H\end{array}\right.$

Calc.	Found. I.	Found. II.
C=41·20	41·15	----
H= 2·00	2·36	----
N=20·05	----	20·33

The mother liquor contained the nitraniline chlorhydrate. The nitraniline was precipitated by sodium hydrate and, after purification, used again.

The reaction is exactly analogous to the one representing the formation of trinitroaniline (loc. cit.).

$$C^6H^2(NO^2)^3Cl+2C^6H^4(NO^2)NH^2=N\left\{\begin{array}{l}C^6H^4(NO^2)\\ C^6H^2(NO^2)^3\\ H+C^6H^4(NO^2)NH^2\cdot HCl\end{array}\right.$$

Solubility.—Almost entirely insoluble in hot water, coloring it yellow, however; hardly soluble in boiling ether, carbon disulphide, carbon tetrachloride, chloroform, and absolute alcohol. Insoluble in chlorhydric, nitric (dil.) and sulphuric (dil.) acids. Easily soluble in concentrated sulphuric acid to a deep red wine color, and is separated unchanged in the form of yellow flocks on the addition of water. In aniline it is easily soluble with a beautiful red color. In hot amyl-alcohol it is easily soluble, but crystallizes badly therefrom. In hot glacial acetic acid it is easily soluble, and separates in the form of a beautiful orange-red crystalline sand. From a solution in acetylchloride it crystallizes in small wine-yellow transparent crystals.

Aqueous ammonia dissolves it very easily, the solution attaining a splendid scarlet-red color. By evaporation it separates unchanged. In weak aqueous solutions of alkalies it behaves as with ammonia. Concentrated solutions of sodium and potassium hydrates, especially by heating, decompose it with evolution of ammonia.

Properties.—The compound consists of a heavy, crystalline, yellow sand, fusing at 205° to a red liquid which, when undisturbed, solidifies at about 175°. By careful heating it volatilizes in the form of a yellow powder. It burns with a yellow luminous flame when heated on a platinum foil, and leaves a porous coal. If it be thrown on a hot surface it explodes like gunpowder. By percussion it is not explosive.

Alphatrinitrophenylparanitraniline.

Preparation.—This compound was made in a manner similar to the preceding one. Paranitraniline (made by nitrition of acetanilide, elimination of the acetyl-group by boiling with concentrated chlorhydric acid, and decomposition of the nitraniline chlorhydrate by sodium hydrate) with the calculated amount of picryl chloride was brought into solution in boiling absolute alcohol. On continuing the boiling, a red crystalline powder separated.

Analysis.—The substance was purified by crystallization from glacial acetic acid, dried at 100°, and analyzed.

0·2888 grms. of substance burned with lead chromate gave 0·4354 grms. of CO^2 and 0·5920 grms. of H^2O.

0·2852 grms. of substance gave $V=49\cdot8$ c.c. [$B=767$mm.; $t=23°$].

$$\text{The formula } N\left\{\begin{array}{l}C^6H^4(NO^2)_p\\ C^6H^2(NO^2)^3{}_\alpha\\ H\end{array}\right.=C^{12}H^7N^5O^8$$

Calc.	Found. I.	Found. II.
C=41·26	41·12	....
H= 2·00	2·27	....
N=20·05	....	20·07

Solubility.—The solubility of this compound is nearly the same as the preceding one, being, in general, somewhat higher. In aqueous ammonia it is easily soluble to a red color. Acids precipitate it unchanged from this solution. From alcoholic ammonia it crystallizes in beautiful glittering leaves.

It dissolves in a warm solution of sodium carbonate to a scarlet-red color. On cooling, violet needles separate. This, without doubt, is the sodium salt of the alphapicrylparanitraniline, $N\left\{\begin{array}{l}C^6H^4(NO^2)_p\\ C^6H^2(NO^2)^3{}_\alpha\\ Na\end{array}\right.$ The needles are soluble in alcohol and water, and are decomposed by acids.

It is insoluble in an aqueous solution of ammonium carbonate. Easily soluble in amyl alcohol, crystallizing therefrom in bright, glittering, yellow scales. In aniline it dissolves easily, and separates on evaporation in a crystalline form. It is also quite soluble in benzoyl chloride, acetyl chloride, benzyl chloride and chlorbenzol.

Properties.—In general this compound seems to possess more acid properties than its isomer. The pure substance fuses at 216°.

Dinitrophenylmetanitraniline.

Preparation.—Calculated amounts of dinitrobrombenzol (produced by nitrition of brombenzol) and metanitraniline were rubbed to a pap with absolute alcohol, and the mixture heated twenty hours at 100° in a closed tube. The reaction took place in the most satisfactory manner.

On cooling, the tube contained hard brown crystals. They were washed on a filter with warm alcohol until the filtrate contained no trace of nitraniline chlorhydrate.

Analysis.—The substance was purified by repeated crystallization from an excess of glacial acetic acid, dried at 100°, and analyzed.

0·2780 grms. of substance burnt with lead chromate gave 0·0896 grms. of H^2O and 0·4844 grms. of CO^2.

0·2822 grms. of substance gave V=46 c.c. [B=757·2 mm.; *t*=22·2°].

$$\text{The formula } N\left\{\begin{array}{l} C^6H^4(NO^2)_m \\ C^6H^3(NO^2)^2{}_p \\ H \end{array}\right. = C^{12}H^8N^4O^6$$

Calc.	Found. I.	Found. II.
C=47·36	47·81	----
H= 2·63	3·57	----
N=18·42	----	18·66

Solubility.—The substance is insoluble in water, alcohol and ether. Difficultly soluble in boiling glacial acetic acid. It is soluble in an excess of boiling chloroform, separating in small yellow crystals.

Properties.—Small glittering yellow crystals, fusing at 189°[*] to a red liquid. With alkalies it behaves in the same manner as the trinitrophenylparanitraniline.

Dinitrophenylparanitraniline.

Preparation.—The calculated amounts of dinitrobrombenzol and paranitraniline were treated as in the production of the preceding compound. On cooling the tube contained a mass of dark-red crystals. They were washed with dilute alcohol.

Analysis.—As the substance did not crystallize from any solvent, it was purified by solution in glacial acetic acid and precipitation by water. In this manner, bright yellow flocks were obtained. After three repetitions of the solution, precipitation, and washing, the substance was dried at 100° and analyzed.

0·3080 grms. of substance burnt with lead chromate gave 0·5386 grms. of CO^2 and 0·0912 grms. of H^2O.

0·2348 grms. of substance gave V=37·6° [B=755·3 mm.; *t*=19°].

$$\text{The formula } N\left\{\begin{array}{l} C^6H^4(NO^2)_p \\ C^6H^3(NO^2)^2{}_p \\ H \end{array}\right. = C^{12}H^8N^4O^6$$

Calc.	Found. I.	Found. II.
C=47·36	47·68	----
H= 2·63	3·29	----
N=18·42	----	18·29

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[*] Wilgerodt announced (in Ber. Chem. Ges., ix, 1178) a dinitrophenylmetanitraniline which he had produced by the action of $\alpha\, C^6H^3(NO^2)^2Cl$ on metanitraniline. This is perhaps identical with my compound, although he finds a fusing point of 194–5°.

Solubility.—The substance is *easily soluble in cold glacial acetic acid.* It here shows a striking difference from the dinitrophenylmetanitraniline which is *difficultly soluble in boiling glacial acetic acid.* It is difficultly soluble in cold absolute alcohol, easily in hot.

Properties.—The compound forms a light-yellow and extraordinarily light, elastic and electric powder. It fuses at 181°. Owing to the small amount of the substance at my disposal, I have not been able to investigate its properties more thoroughly.

Since the picrylnitranilines contain the mononitrophenyl-group, it appeared extremely probable to me that a further nitrition could be effected. In this case, since the trinitrophenyl-group seems to be the limit of direct nitrition of the phenyl-group, I could predict* that by the nitrition of the picrylnitranilines, higher nitro-members would be formed, and that the nitro-groups would enter into the mononitrophenyl-group. If, then, by the nitrition of the picrylnitranilines, higher isomeric nitro-compounds were obtained, the isomerism must reside in the nitrized mononitrophenyl-group, since the trinitrophenyl-group remains unchanged during the nitrition.†

It is, however, very possible that in *one* of the resulting compounds the two picryl-groups may be identical.

Since the positions of the nitro-groups in these dipicrylamines has not been ascertained, I shall represent the trinitrophenyl-group of picric acid by α, and the dinitromononitrophenyl-groups of meta and paranitraniline by β and γ respectively. Only two of these picryl-groups can be identical.

*** Supposing that the imido-group would withstand the action of the nitrous acid.**

† That is, we suppose it does. The supposition will doubtless remain synonymous with the fact for some time to come. Picric acid remains unchanged by the action of nitrizing agents. Hence we suppose that this trinitrophenyl-group when combined in the picrylnitraniline also remains unaltered during nitrition. I have no proof, however, that the introduction of two nitro-groups into the mononitrophenyl-group does not exert a displacing action on the members of the picryl-group.

In nitrizing the paradibrombenzol, I find that the relative amounts of isomers formed are not constant. This seems to depend on the strength and the amounts of the acids used as well as on the duration and temperature of the heating. I am, at present, endeavoring to determine this more exactly, in the hope of being able to produce more of a given isomer at will.

An interesting field is opening in regard to whether several isomers are formed at once, or whether one is formed first and the others from it by atomic migration. If the latter is the case, then the production of relative amounts of isomers is partly under control. In this connection it is interesting to remark that Doer (Ber. Chem. Ges., v, 795. Compare Hlasiwetz, Wien. Acad. Ber., xxiv, 237) by nitrition of diphenylmethane obtained a dinitro-compound, while by continued digestion of the nitrition mixture he got an isodinitro-compound. 1·4 nitrophenol is formed in the cold, the 1·2 compound, however, by heating (Jahresbericht, 1875, 364).

Alphapicrylbetapicrylamine.

Preparation.—The alphapicryl-metanitraniline was added in small portions to a cooled mixture of equal volumes of fuming nitric and concentrated sulphuric acids. The liquid became hot, and a violent reaction set in. After the reaction had subsided, the liquid was poured into cold water. A bright sulphur-yellow cream was in this manner obtained. If, however, the acid solution is boiled for half an hour, the substance is completely destroyed, and, on pouring the liquid into water, only a resin is obtained.

After washing out the acid with water, the cream was well extracted with alcohol, by which means a resin, giving a deep orange-red solution, was removed. The substance was then dissolved in boiling glacial acetic acid, and precipitated by concentrated chlorhydric acid, well washed with dilute chlorhydric acid, dissolved again in boiling glacial acetic acid, boiled some time with animal charcoal, filtered, and allowed to crystallize.

Analysis.—A portion of the substance was purified by crystallization from glacial acetic acid, dried at 100°, and submitted to analysis.

0·2876 grms. of substance gave 0·3490 grms. of CO^2 and 0·0404 grms. of H^2O.

0·2924 grms. of substance gave 0·3538 grms. of CO^2 and 0·0404 grms. of H^2O.

$$\text{The formula } N\left\{\begin{array}{l} C^6H^2(NO^2)^3\beta \\ C^6H^2(NO^2)^3\alpha = C^{12}H^5N^7O^{12} \\ H \end{array}\right.$$

Calc.	Found. I.	Found. II.
C=32·8	33·09	32·99
H= 1·13	1·56	1·53

Solubility.—It is almost insoluble in hot water, coloring it, however, slightly yellow. Chlorhydric, nitric and sulphuric acids do not increase its solubility in water. In hot amyl and ethyl alcohols it is almost insoluble, hardly soluble in ether, carbon tetrachloride, carbon disulphide, and chloroform. In cold glacial acetic acid, difficultly soluble, in the hot acid, it dissolves easily. In aniline, it is easily soluble.

In aqueous ammonia, sodium and potassium hydrates, it dissolves easily with a superb scarlet color.

Properties.—Impalpable bright sulphur-yellow powder. By careful crystallization from glacial acetic acid, it can be obtained in small transparent glittering crystals. It fuses at 261° to a red liquid, which at 175°–170° solidifies to a red glass. By touching it with a hard object when in a liquid state, it solidifies to a yellow amorphous mass.

Vapors of ammonia turn it scarlet. By boiling with moderately concentrated solutions of sodium and potassium hydrates, it decomposes with evolution of ammonia. In an aqueous solution of sodium carbonate it dissolves easily, forming the sodium salt.

By addition of water to the boiling glacial acetic acid solution, a thick precipitate is formed, which, after crystallization from glacial acetic acid, showed a fusing point of 205°, and on analysis proved to be the original picrylmetanitraniline from which this dipicrylamine had been prepared. *By the addition, then, of water, to the boiling solution in glacial acetic acid, the alphabetadipicrylamine loses two nitro-groups and is converted back into the picrylmetanitraniline.*

The dipicrylamine does not explode by percussion. If heated, it puffs with a white luminous flame, and leaves a light porous coal. It explodes with violence when thrown on a hot platinum foil.

Alphapicrylgammapicrylamine.

Preparation.— This compound was prepared by nitrition of the picrylparanitraniline in the same manner as in the case of the preceding compound. On pouring the resulting mixture into cold water, the substance separated as a light greenish-yellow cream. After extraction with alcohol it was crystallized from glacial acetic acid, dried at 100°, and analyzed.

Analysis.—

0·2836 grms. of substance burnt with lead chromate gave 0·3480 grms. of CO^2 and 0·0436 grms. of H^2O.

0·2792 grms. of substance gave V=54·3c.c.[B=756^{mm}; t=22°].

$$\text{The formula } N\left\{\begin{array}{l} C^6H^2(NO^2)^3\gamma \\ C^6H^2(NO^2)^3\alpha = C^{12}H^5N^7O^{12} \\ H \end{array}\right.$$

Calc.	Found.	
	I.	II.
C=32·80	32·08	....
H= 1·13	1·70	....
N=22·32	....	21·91

Solubility.—The solubility is about the same as that of the preceding compound.

Properties.—Small transparent glittering light-yellow prisms with a green reflex. It fuses at 230° with effervescence and decomposition. It puffs on being heated, and explodes with violence when thrown on a hot surface. With alkalies, it behaves like the alphabeta-compound.

I have already mentioned that these compounds, particularly the dipicrylamines, give fine scarlet colors with alkalies, According to Hofmann, the mono- and dinitrophenylamines give similar ones. This fact was substantiated by Clemm.

I find that these colors are caused by the formation of salts of the nitrodiphenylamines. The hydrogen atom of the imido-group has become so negative by the introduction of the nitro-groups, that it can easily be substituted by basic atoms. It reacts easily, indeed, with carbonates of the alkalies.

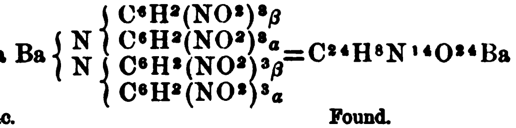
Of the numerous salts of these compounds which I have prepared, I have as yet had time only to investigate one—the barium salt of the alphabetadipicrylamine.

Barium-alphapicrylbetapicryldiamine.

Preparation.—The $\alpha\,\beta$-picrylamine was added to an aqueous pap of barium hydrate (or carbonate). The dipicrylamine dissolved immediately with a deep intense red color. The solution was boiled for a few minutes and then evaporated on a water-bath. After a sufficient concentration had been obtained, the solution was allowed to stand. A beautiful crystallization of dark-red needles was obtained. They were purified by repeated crystallization from water.

Analysis.—A portion of the needles were dried at 100° and mixed with sodium carbonate and nitrate. Some sodium carbonate was then fused in a platinum crucible, and the mixture added to it in small portions. The resulting solution was kept in fusion about five minutes, and then allowed to cool. After it had become quite cold it was dissolved in very dilute chlorhydric acid, filtered, the solution brought to boiling, and precipitated with sulphuric acid.

0·4012 grms. of substance gave 0·0908 grms. of $BaSO^4$.



The formula $$Ba\left\{\begin{array}{c} N\left\{\begin{array}{l} C^6H^2(NO^2)^3{}_\beta \\ C^6H^2(NO^2)^3{}_\alpha \end{array}\right. \\ N\left\{\begin{array}{l} C^6H^2(NO^2)^3{}_\beta \\ C^6H^2(NO^2)^3{}_\alpha \end{array}\right. \end{array}\right. = C^{24}H^8N^{14}O^{24}Ba$$

Calc.	Found.
Ba=13·52	13·30

The reaction by which this barium salt is formed is very simple:

$$2(NH[C^6H^2(NO^2)^3]^2)+Ba(OH)^2=Ba[N(C^6H^2(NO^2)^3)^2]^2+H^2O$$

Solubility.—Quite easily soluble in boiling water, less so in alcohol.

Properties.—Small, dark saffron-red glittering needles. It seems to have enough basic properties to form salts with weak acids. This interesting fact I hope shortly to prove. If it be brought into a flame, it explodes in a remarkable manner, flying through the air with brilliant coruscations, and giving a beautiful barium-flame. Thrown on a hot surface it explodes with great violence.

With the hydrates and carbonates of the metals, the dipicrylamine yields in the same manner fine salts.

The most beautiful salt which I have yet obtained is the ammonium-alphagammapicrylamine. It crystallizes in superb intense red transparent rhombohedrons (?). Whether it is identical or only isomeric with the dyestuff "Aurantia," which is now produced on a large scale, I have not had an opportunity of ascertaining.

By treatment of the sodium salts of the dipicrylamines with picrylchloride, a reaction takes place doubtless with the formation of the tertiary picrylamine, $N(C^6H^2(NO^2)^3)^3$.

Immediately after the publication of my preliminary notice, Gnehm* announced some new nitrodiphenylamines which he had obtained by nitrition of methyldiphenylamine, the methyl-group having been eliminated during the operation.†

The following table will show the various nitrodiphenylamines known, their method of preparation, and properties.

No.	Rational Formula.	Empirical Formula.	Remarks.
I.	$N\left\{\begin{matrix}C^6H^5\\ C^6H^4(NO^2)\\ CO.C^6H^5\end{matrix}\right.$	$C^{19}H^{14}N^2O^3$	Hofmann, HNO^3 on $N\left\{\begin{matrix}(C^5H^5)^2\\ CO.C^6H^5\end{matrix}\right.$ Light-yellow crystals.
II.	$N\left\{\begin{matrix}C^6H^5\\ C^6H^4(NO^2)\\ H\end{matrix}\right.$	$C^{12}H^{10}N^2O^2$	Do., NaOH on No. I.
III.	$N\left\{\begin{matrix}C^6H^4(NO^2)\\ C^6H^4(NO^2)\\ CO.C^6H^5\end{matrix}\right.$	$C^{19}H^{13}N^3O^5$	Do., fuming HNO^3 on $N\left\{\begin{matrix}(C^6H^5)^2\\ CO.C^6H^5\end{matrix}\right.$ Deep yellow crystalline substance.
IV.	$N\left\{\begin{matrix}C^6H^4(NO^2)\\ C^5H^4(NO^2)\\ H\end{matrix}\right.$	$C^{12}H^9N^3O^4$	Do., NaOH on No. III. Red-yellow needles with metallic blue reflex.
V.	$N\left\{\begin{matrix}C^6H^5\\ C^6H^3(NO^2)^2_m\\ H\end{matrix}\right.$	$C^{12}H^9N^3O^4$	Clemm, $C^6H^3(NO^2)^2Br$ on $C^6H^5NH^2$. Long thin scarlet-red or red-yellow glittering needles. Fuses at 153°. Wilgerodt, a-$C^6H^3(NO^2)^2Cl$ on alcoholic H^2S-solution of aniline. Fuses at 156°–157°

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* Ber. Chem. Ges., vii, 1399.

† The elimination of a group during nitrition is quite frequent. Tribrommethyldiphenylamine gives dibromtetranitrodiphenylamine [Gnehm] (Ber. Chem. Ges., viii, 930): tetrahydroisoxyloldicarboxyl (camphoric acid) yields trinitroisoxylol, under elimination of hydroxyl and carboxyl [Wreden] (ibid., v, 1106): many sulphonic acids part with the sulpho-group during nitrition. Cresolsulphonic acid gives trinitrocresol [Duclos] (Ann. Chem. Pharm., cix, 135) and dinitrocresol [Armstrong and Field] (Chem. News, xxvii, 318); dichlorphenolsulphonic acid yields a nitrochlorphenol [Armstrong] (Chem. Soc. Jour. [2], ix, 1112): monochlorphenolsulphonic acid, from solid chlorphenol, gives dinitrochlorphenol [Petersen and Baehr-Predari] (Ann. Chem. Pharm., clvii, 121): the monochlorphenolsulphonic acid from liquid chlorphenol behaves in a similar manner [Armstrong and Prevost] (Ber. Chem. Ges., vii, 404): sulphopodocarpinic acid yields dinitropodocarpinic acid [Oudemans] (ibid., vii, 1317). By nitrition of benzoylnaphthylamine, Hübner and Ebell (Ann. Chem. Pharm., clxx, 212) think they obtained a small amount of nitronapthylamine. In the nitrition residues of diphenyl, Fittig (ibid., cxxiv, 275) detected small amounts of nitrobenzol.

VI.	$N\left\{\begin{matrix}C^6H^5\\C^6H^2(NO^2)^3_\alpha\\H\end{matrix}\right.$	$C^{12}H^8N^4O^6$	Do., $C^6H^2(NO^2)^3Cl$ on $C^6H^5NH^2$. Sparkling prisms. By reflection scarlet-red; by refraction reddish-yellow. Fuses at 175°.
VII.	$N\left\{\begin{matrix}C^6H^4(NO^2)_m\\C^6H^3(NO^2)^2_m\\H\end{matrix}\right.$	$C^{12}H^8N^4O^8$	Austen, $C^6H^3(NO^2)^2Br$ on *m*-nitraniline. Small glittering yellow crystals. Fuses at 189°.
VIII.	$N\left\{\begin{matrix}C^6H^4(NO^2)_p\\C^6H^3(NO^2)^2_m\\H\end{matrix}\right.$	$C^{12}H^8N^4O^6$	Do., $C^6H^3(NO^2)^2Br$ on *p*-nitraniline. Light electrical yellow powder. Easily soluble in cold glacial acetic acid. Fuses at 181°.
IX.	$N\left\{\begin{matrix}C^6H^4(NO^2)_m\\C^6H^2(NO^2)^3_\alpha\\H\end{matrix}\right.$	$C^{12}H^7N^5O^8$	Do., $C^6H^2(NO^2)^3Cl$ on *m*-nitraniline. Heavy cryst. yellow sand, or wine-yellow transparent crystals. Fuses at 205°.
X.	$N\left\{\begin{matrix}C^6H^4(NO^2)_p\\C^6H^2(NO^2)^3_\alpha\\H\end{matrix}\right.$	$C^{12}H^7N^5O^8$	Do., $C^6H^2(NO^2)^3Cl$ on *p*-nitraniline. Red crystalline powder, or glittering scales. Fuses at 216°.
XI.	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\beta\\C^6H^2(NO^2)^3_\alpha\\H\end{matrix}\right.$	$C^{12}H^5N^7O^{12}$	Do., nitrition of IX. Fuses at 261°. Impalpable bright yellow powder or small transparent glittering yellow crystals.
XII.	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\gamma\\C^6H^2(NO^2)^3_\alpha\\H\end{matrix}\right.$	$C^{12}H^5N^7O^{12}$	Do., nitrition of X. Small transparent glittering bright yellow prisms with green reflex. Fuses at 230°.
XIII.	$Ba\left\{\begin{matrix}N\\N\end{matrix}\right.\left\{\begin{matrix}C^6H^2(NO^2)^3_\beta\\C^6H^2(NO^2)^3_\alpha\\C^6H^2(NO^2)^3_\beta\\C^6H^2(NO^2)^3_\alpha\end{matrix}\right.$	$C^{24}H^8N^{14}O^{24}Ba$	Do., $Ba(OH)^2$ on XI. Dark saffron-red glittering needles. Explodes on heating.
XIV.	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\,?\\C^6H^2(NO^2)^3\,?\\H\end{matrix}\right.$	$C^{12}H^5N^7O^{12}$	Gnehm, nitrition of diphenylamine. Transparent light-yellow prisms. Fuses at 238°.
XV.	$N\left\{\begin{matrix}C^6H^2(NO^2)^3\,?\\C^6H^2(NO^2)^3\,?\\NH^4\end{matrix}\right.$	$C^{12}H^8N^8O^{12}$	Do., NH^3 on XIV. Beautiful red leaves.
XVI.	$N\left\{\begin{matrix}C^6H^2Br(NO^2)^2\,?\\C^6H^2Br(NO^2)^2\,?\\H\end{matrix}\right.$	$C^{12}H^5N^5Br^2O^8$	Do., nitrition of $HN\left\{\begin{matrix}C^6H^4Br\\C^6H^3Br^2\end{matrix}\right.$. Yellow pearly leaves or rhombic tablets. Fuses at 235°–240°–242°.
XVII.	$N\left\{\begin{matrix}C^6H^2(NO^2)^2Br\,?\\C^6H^5\\H\end{matrix}\right.$	$C^{12}H^8N^3BrO^4$	Austen, $C^6H^5.NH^2$ on $C^6H^3\left\{\begin{matrix}(NO^2)^2_\beta\\Br^2_p\end{matrix}\right.$ Beautiful red-orange, fine hairy needles. Fuses at 120°. (This Journal, xii, 118.)
XVIII.	$N\left\{\begin{matrix}C^6H^2(NO^2)^2Br\,?\\C^6H^3(NO^2)^2\,?\\H\end{matrix}\right.$	$C^{12}H^5N^5BrO^8$	Do., nitrition of XVII. Small brown scales. Fuses at 167·5°.
XIX.	$N\left\{\begin{matrix}C^6H^3(NO^2)^2\,?\\C^6H^4.C^6H^4.NH^2\,?\\H\end{matrix}\right.$	$C^{18}H^{14}N^4O^4$	Wilgerodt, α-$C^6H^3(NO^2)^2Cl$ on benzidine. Short bluish brown-red needles. Fuses at 255°. (Ber. Chem. Ges., ix, 977.)
XX.	$N\left\{\begin{matrix}C^6H^3(NO^2)^2\,?\\C^6H^4.C^6H^4.NH\ C^6H^3[(NO^2)^2]\\H\end{matrix}\right.$	$C^{24}H^{16}N^6O^8$	Do., formed with XIX. Yellow pulverulent. Sol. in conc. H^2SO^4 with a violet color. Fuses at 330°.
XXI.	$N\left\{\begin{matrix}C^6H^3(NO^2)Clm\\C^6H^5\\H\end{matrix}\right.$	$C^{12}H^9N^2ClO^2$	Laubenheimer. Action of $C^6H^3(NO^2)Cl^m$. NO^2 on aniline. Long glittering alizarine-red needles. Fuses at 108·5°.

University Laboratory of Berlin, August 30, 1876.
(School of Mines, New York, January 3, 1877.)

ART. XXXIII.—*Note on Mineral Analysis; Notes upon some Fluorides; and Note on Molecular Volumes;* by F. W. CLARKE, S.B., Professor of Physics and Chemistry.—*Laboratory Notes from the University of Cincinnati.* Nos. I to III.

I. *Note on Mineral Analysis.*

IN 1868,* the writer called attention to the fact that certain very refractory minerals are easily rendered soluble by fusion with a mixture of sodium fluoride and acid potassium sulphate. He now finds that in many cases, and with but little loss of power, common salt may replace the fluoride, the mode of manipulation remaining the same. The finely pulverized mineral is to be mixed with three parts of the chloride in a capacious platinum crucible, and the mixture covered with twelve or fifteen parts of the acid sulphate in small fragments. The fusion is then performed over an ordinary Bunsen's flame, and in five or six minutes is complete. The fused mass, after cooling, detaches readily from the crucible, and shows upon its smooth under surface no traces of undecomposed assay.

This method is not by any means equal to the original process with sodium fluoride, either in speed or in generality of application; still, in some cases, it is convenient. Sodium fluoride is expensive, and not always immediately to be obtained; hence the desirability of a substitute. Perhaps my new observation might better be stated thus: that whenever a mineral is resolvable by fusion with the acid sulphate alone, the action is very much facilitated by the addition of common salt.

The new fusing mixture will probably prove to be most serviceable in the analysis of refractory iron ores and of chromite. The latter mineral, after fusion with chloride and bisulphate, furnishes a green mass completely soluble in dilute hydrochloric acid. Or this mass may be treated directly with strong nitric acid and potassium chlorate, after the method of Storer and Pearson, and all the chromium oxidized at once to chromic acid. Precipitation of the chromium as mercurous chromate is then possible, but not wholly convenient. Several unsuccessful efforts were made to carry out the oxidation of the chromium in the course of the fusion itself. With the sodium fluoride or chloride, sodium nitrate or potassium chlorate was mixed. Then upon fusing with the acid sulphate, partial oxidation ensued, but in no case did more than a small fraction of the chromium seem thus to be affected.

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* This Journal, March, 1868.

II. *Notes upon some Fluorides.*

Nickel fluoride.—This salt was prepared by dissolving nickel hydrate in aqueous hydrofluoric acid. Upon concentrating the dark green fluid a granular mass of crystals separated out; which, according to water determinations made by Mr. John Hagemann, had the composition $NiF_2.3H_2O$. The last portions of water were retained up to the temperature of 130°. Percentage of water found, 35·98; calculated, 35·81. Specific gravity, 2·014 at 19°. The anhydrous fluoride, NiF_2, had the density 2·855 at 14°. These specific gravity determinations were made in an ordinary specific-gravity bottle, chloroform being the liquid employed.

On two accounts these observations are interesting. First, because the hydrated salt is evidently new, the crystallized nickel fluoride described by Berzelius having contained but two molecules of water. Secondly, the molecular volume of the water in this new hydrate is 13·65; corresponding very closely with the average value of 13·76, deduced by the writer from the study of over thirty different salts, and stated in his paper of two years ago.*

Attempts to prepare a double fluoride of nickel and silver met with but indifferent success. In several experiments the mixed solutions of the two fluorides yielded upon concentrating only the nickel salt alone; the silver compound apparently decomposing. In one instance, however, pale apple-green needles were deposited, mixed with some microscopic rhombohedrons. Upon recrystallizing, about two-tenths of a gram of these crystals were obtained, both forms being represented, and, to the naked eye, both consisting of one and the same substance. A qualitative examination showed them to be a true double fluoride of nickel and silver, highly hydrated; but not sufficient in quantity for a thorough analysis. The silver in them amounted to a trifle less than twenty per cent, a proportion which agrees with no probable formula.

Zinc fluoride.—The only new fact for me to record concerning this salt is its density. Two distinct samples of the crystallized compound, $ZnF_2.4H_2O$, obtained from a solution of zinc in hydrofluoric acid, gave respectively 2·567 at 10°, and 2·535 at 12°. The anhydrous fluoride gave in one experiment a specific gravity of 4·556 at 17°, and in another 4·612 at 12°. These figures are noticeable from the fact that they do not agree with the usual molecular volume of water of crystallization. They yield a volume of water ranging from 11·4 to 11·8; an amount considerably below the usual value. I will not now hazard any conjectures as to the meaning of this apparent exception.

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* This Journal, December, 1874.

The writer has also determined the specific gravities of several alkaline fluorides, as follows: Lithium fluoride, 2·295, 21·5°; sodium fluoride, 2·558, 14·5°; potassium fluoride, 2·096, 21·5°. According to Bödeker, potassium fluoride has a density of 2·454 at 12°. Theoretical considerations, to be cited in the third part of this paper, sustain the lower value as obtained by me. An examination of rubidium fluoride, made upon a very small quantity of material, may not prove to be wholly trustworthy. It gave a specific gravity of 3·102 at 17°. Rubidium carbonate was dissolved in hydrofluoric acid, the solution evaporated to dryness in a platinum dish, and the residue fused at a heat just below redness. The molten fluoride was so transparent as to be almost invisible in the vessel containing it; but, upon cooling, it became white and opaque, and contracted so strongly as to split up into several fragments. This salt is extremely deliquescent.

Attempts to prepare fluorides of gold and platinum were wholly unsuccessful. Still, results were obtained which may be worth recording. To a solution of gold chloride, silver fluoride was added, in order that by double decomposition silver chloride might be thrown down and gold fluoride formed. In fact, however, there fell a pale-brown precipitate which grew rapidly darker in color, and which consisted of silver chloride mixed with gold oxide. The reaction may be expressed as follows:

$$2AuCl_3+6AgF+3H_2O=Au_2O_3+6AgCl+6HF.$$

With platinum tetrachloride and silver fluoride a pale-yellow precipitate was formed, containing platinum dioxide, thus:

$$PtCl_4+4AgF+2H_2O=PtO_2+4AgCl+4HF.$$

The same precipitates are formed when silver nitrate is used instead of fluoride, nitric acid being set free in place of hydrofluoric. This has long been known, the reactions being new only in so far as they involve the effect of silver fluoride. This statement is made so that perhaps some other investigators may be saved from tedious and fruitless experimenting.

III. *Note on Molecular Volumes.*

Several years ago, in a series of papers upon atomic or molecular volumes, I pointed out some curious multiple relations connecting both elements and compounds.* For example, I found that a simple relation of this kind connected the alkaline metals with each other; and, later, that the haloid salts of some of these metals had molecular volumes multiples of that of hydrogen. For this latter relation, however, my materials were meager. I had then the specific gravity determinations for LiCl, NaCl, KCl, NaBr, KBr, NaI, and KI, or seven compounds in all. To these I added, though unsatisfactorily, the corresponding salts of silver, making a list of ten bodies closely related, and giving volumes multiples of 5·5, the value assigned by Kopp to hydrogen in its liquid compounds, at their boiling points. This relation I am now able to extend, partly by new density observations of my own, to include at least twelve compounds not in my earlier list.

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* This Journal, March and May, 1869; September, 1870.

My own determinations, in addition to those I have already given for the alkaline fluorides, are as follows: Rubidium chloride, 2·209, 19°; rubidium bromide, 2·780, 17·5°; rubidium iodide, 3·023, 22°; lithium bromide, 3·102, 17°; lithium iodide, 3·485, 23°.

Now let us tabulate the material. The first column contains the symbol of the substance, the second its density with authority given, the third its molecular volume as found, the fourth its volume calculated, the fifth a theoretical density deduced from this volume. The calculated volumes are of course the exact multiples of Kopp's hydrogen value, and will be seen at once to agree closely with the results of experiment. The real variation between fact and theory, however, will be best seen upon comparing the two columns of densities. The differences here are always less than 0·1.

I.	II.	III.	IV.	V.
Li F.	2·295, Clarke.	11·33	11·00	2·363
Li Cl.	1·998, Kremers.	21·27	22·00	1·932
Li Br.	3·102, Clarke.	28·05	27·50	3·164
Li I.	3·485, "	38·45	38·50	3·481
Na F.	2·558, "	16·41	16·50	2·545
Na Cl.	2·145, Buignet.	27·27	27·50	2·127
Na Br.	3·079, Kremers.	33·45	33·00	3·121
Na I.	3·450, Filhol.	43·48	44·00	3·409
K F.	2·096, Clarke.	28·20	27·50	2·113
K Cl.	1·945, Kopp.	38·35	38·50	1·937
K Br.	2·672, Playfair, Joule.	44·57	44·00	2·707
K I.	3·056, Filhol.	54·35	55·00	3·020
Rb F.	3·202, Clarke.	32·64	33·00	3·167
Rb Cl.	2·209, "	54·78	55·00	2·200
Rb Br.	2·780, "	59·53	60·50	2·735
Rb I.	3·023, "	70·29	71·50	2·972

Here now we have sixteen compounds of a single type, every one of which agrees with the rule. In each case the molecular volume comes out a multiple of 5·5, or very nearly. Only one substance in the list seems to be in any way abnormal, namely, rubidium fluoride, with its volume of 33. The other fluorides in this group have volumes less by 11 than those of the corresponding chlorides, but in this case the difference is 22. A curious progressive relation is also worth noting. If we compare the five chlorides given in the table we shall see that upon arranging them in the order of their molecular weights the differences between successive members of the series increase as we ascend. Thus LiCl and NaCl differ by 5·5, NaCl and KCl by 11, KCl and RbCl by 16·5. This regular difference-increase is certainly suggestive of some law yet to be clearly made out.

A similar relation to Kopp's hydrogen volume is also afforded by the two other compounds. Sodium hydride, Na_2H, discovered by Troost and Hautefeuille,* with a density of 0·959, has a molecular volume of 49·1, or very nearly 5·5×9. Still more interesting is iodine monochloride, so carefully studied by Hannay.† At 0° the solid substance has a specific gravity of 3·263, and a molecular volume of 49·8, thus varying only 0·3 from a multiple of 5·5. At 101° the chloride boils, and at 98° its density is 2·958, having a volume of 54·9. Probably an absolutely correct determination at its boiling point would give a value of 55. So we may say that iodine monochloride, both as a solid at 0°, and as a liquid at its boiling point, has molecular volumes multiples of that of hydrogen.

As for the haloid salts of silver, they cannot with certainty be included among the substances connected by this multiple relation. The fluoride agrees fairly, however, having a density of 5·852, Gore, and a molecular volume of 21·7 instead of 22. The chloride and iodide may be forced to agree by selecting out the density determinations of certain investigators, and rejecting other decidedly discordant data. The bromide does not agree at all. A determination of my own for precipitated AgBr gives a density of 6·215, 17°, and a corresponding volume of 30·25. Other determinations are even more discordant than this. Silver salts generally have molecular volumes equal or nearly equal to the corresponding sodium compounds; that of sodium bromide being 33·0. Silver fluoride, it will be seen, diverges also from the sodium salts. For thallium, our data are insufficient. Its monochloride has a molecular volume approximating to a multiple of 5·5, but not closely enough to be satisfactory. The sesquichloride does not even approximate. At some future time I hope to be able to revise and extend our specific gravity determinations for this class of thallium salts.

Now to sum up. Including the silver and thallium salts we know the densities of twenty-five substances containing only univalent elements. Of these, twenty have molecular volumes multiples of that of hydrogen, three are doubtful, two apparently disagree. We may, therefore, safely assert the following general law, subject to possible exceptions. *Every compound*

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* Compt. Rend., vol. lxxviii, 970.

† Jour. Chem. Soc., II, xi, 818.

containing only elements of the hydrogen group has a molecular volume an even multiple of that of hydrogen. This is probably but a hint of some more general regularity connecting other elements and other groups.

Postscript.—Since the above pages were written, there has been published by Johnson a density determination for potassium triiodide, KI_3. (Chem. News, xxxiv, 256.) This determination, 3·498, corresponds to a molecular volume of 120·1. 121 is an exact multiple of 5·5, and gives a theoretical density of 3·472. The multiple relation now holds good in twenty cases out of twenty-five.

ART. XXXIV.—*On the identity of the so-called Peganite of Arkansas with the Variscite of Breithaupt and Callainite of Damour;*

by ALBERT H. CHESTER.

A NUMBER of years ago I obtained some specimens of a mineral, said to come from Colorado, which, after a hasty examination, was called peganite. More recently, I have received specimens of the same mineral from Montgomery County, Arkansas, from which locality the first undoubtedly came. Analyses were made of both, with the results given below; No. 1 is of the amorphous mineral, and No. 2 is the average of two analyses of the crystalline variety. It was found impossible to separate it from the quartz with which it is associated, and a considerable quantity of the latter substance is unavoidably included in each analysis.

	1	2
Phosphoric acid	13·08	22·36
Alumina	9·59	15·72
Water	7·08	11·89
Insoluble residue	69·69	49·86
Total,	99·44	99·83

Deducting the insoluble residue, and calculating to one hundred per cent, we have the results below in columns 1 and 2, while 3 gives the average of the two, and 4 the oxygen ratio.

	1	2	3	4
Phosphoric acid	43·96	44·74	44·35	5·05
Alumina	32·24	31·46	31·85	3·00
Water	23·80	23·80	23·80	4·32

In four other analyses the ratio of water to phosphate of alumina was found to be 1 to 4·04, 4·26, 4·01, and 4·23. The formula for the mineral must then be $Al_2O_3, P_2O_5+4H_2O$, making it distinct from peganite, with which it has been confounded. Its composition, moreover, is identical with that obtained by Petersen for the variscite of Breithaupt, and closely corresponds to that of the callais (callainite) of Damour. Analysis 1, below, is by Petersen (Jahrb. Min., 1871, 357) of variscite from Messbach, in Saxon Voigtland; and analysis 2, one given by Damour (after the deduction of 2·10 p. c. of sand), of callais:

	1	2
Phosphoric acid	44·05	43·31
Alumina	31·25	30·09
Iron sesquioxide [1]	1·21	1·86
Magnesia	0·41	
Lime	0·18	0·70
Water	22·85	24·04
Total,	99·95	100·00

[1] With Cr_2O_3 and FeO.

Both of these analyses agree closely with the formula given, Al_2O_3, $P_2O_5+4H_2O$, which requires: phosphoric acid 44·80, alumina 32·49, water 22·71=100. The mineral from Arkansas with also the callainite of Damour should consequently be included under the name *variscite*, given in 1837 by Breithaupt.

The mineral occurs in crystalline crusts on quartz; also rarely in distinct crystals of very small size. These belong to the orthorhombic system, showing prismatic and basal planes. The crust often presents a semi-globular form with a radiated structure. It also occurs amorphous and disseminated through quartz. The colors observed are deep emerald-green, though all shades of bluish green to almost colorless. Some crystals are dark in the middle, and light at both ends. It is transparent to translucent, infusible, and has a hardness of about 4. Before the blowpipe it becomes opaque, friable, and of a deep purple when hot, lighter purple when cold. In the glass tube yields much water and changes in color as above.

Chemical Laboratory, Hamilton College, Clinton, N. Y., Feb. 12.

ART. XXXV.—*On a fibrous variety of Sepiolite from Utah*; by ALBERT H. CHESTER.

SOME years since I obtained, while visiting a silver mine in Utah, specimens of a fibrous mineral which upon analysis proves to have the composition of sepiolite. It occurs in a seam about two inches in thickness cutting across the rock strata and vein at nearly right angles. The following analyses give the composition of two varieties, one of which is white, and the other bluish-green; 1 is the mean of four analyses of the white variety; 3 is a single analysis of the green kind; and 2 and 4 are the respective oxygen ratios for the two.

	1	2	3	4
Silica	52·97	6·16	50·15	6·08
Alumina	0·86		2·06	
Iron sesquioxide	0·70		1·02	
Manganese sesquioxide	3·14		2·09	
Copper oxide	0·87	2·	6·82	2·
Magnesia	22·50		18·29	
Water	9·90	1·92	9·30	1·88
Moisture	8·80		10·32	

One half the water is driven off at a temperature of 100° C., and very little more is lost even up to 200° C., and a full red heat is required to expel the last traces. It is hence probable that the moisture which goes off below 110° does not belong to the mineral and should not be regarded in deducing the formula. The formula obtained is $2MgO, 3SiO_2+2H_2O$, which is identical with that of sepiolite, of which it is a new and interesting variety. Its blowpipe characters, and its behavior with acids are the same as those of sepiolite. It gelatinizes with hydrochloric acid though not entirely decomposed. The green variety, as shown in the analysis above, contains considerable copper, which is obviously the cause of the color, and which seems to replace the magnesia in the composition of the mineral.

Hamilton College, Feb. 14.

ART. XXXVI.—*On Dr. Peale's Notes on the Age of the Rocky Mountains in Colorado;* by J. J. STEVENSON, Professor of Geology in the University of New York.

I HAVE read Dr. Peale's notes with a good deal of care, but his long discussion of my conclusions contains very little in the way of direct argument, which seems to me to call for a reply. At the same time it is necessary to correct some of Dr. Peale's statements, which, no doubt without any such intention on his part, certainly tend to give a false impression respecting both my facts and my position.

The first of these is on page 172, where the final sentence in the third paragraph seems to intimate that while Dr. Peale does not regard his data as sufficient to extend his generalizations to the entire Rocky Mountain System, I, on the other hand, feel no similar hesitation respecting my data, which were procured within a smaller area. The opening paragraph of Chap. XVII of Wheeler, vol. iii, contains a full statement of my opinion concerning the value of my data.

The second of these is on page 174, in the third paragraph. There the statement is made that the Trias is present in southwestern Colorado and northern New Mexico, and the testimony of Dr. Newberry, Prof. Cope, Mr. Holmes and Dr. Peale is offered to prove the truth of the statement. This effort to show the existence of the Trias there, taken in connection with the fact that no reference is made to my mention of the group in that region, is very apt to leave the impression either that I failed to recognize the group or that I had denied its existence; which would be an error in each case. The occurrence of the Trias in that region is used as a strong proof that Trias occurs in the interior in opposition to my assertion that the group is absent in the interior. With all due respect for Dr. Peale's judgment, I submit that the presence or absence of Trias in New Mexico or southwestern Colorado has nothing to do with the "interior," as those districts are outside of the flexed region, which I called the "interior."

The third of these is on page 176, but begins at the bottom of page 175, where the statement is made that my conclusions in favor of upheaval at the close of the Trias, are based upon unconformability observed at Golden, near Colorado Springs, near Cañon City, and also in Huerfano Park. Dr. Peale at once settles the question here by showing that there is no proof of non-conformability at either Golden or Colorado Springs, so that, as I had made a mistake at each of these localities, there is every reason to believe that the same mistake was made at the other localities. Now I grant him all he says about the conditions at Golden and Colorado Springs; the groups are not in direct contact there, and consequently no proof of non-conformability can be found. But that does not concern this matter in any way. As I made no reference to either Golden or Colorado Springs in this connection, I, of course, made no mistake respecting them, so that Dr. Peale's intimation with regard to the localities to which I did refer, is wholly gratuitous.

The fourth of these statements is in the paragraph beginning at the bottom of page 179, and continuing almost to the bottom of page 180. The reasoning in this paragraph may be ingenious, but one would find difficulty, even by the use of the utmost courtesy, in calling it ingenuous. For the sake of avoiding confusion, as well as for the sake of courtesy, it would have been "best to state" in the text that "Prof. Stevenson regards as Cretaceous" the debatable lignite group which Dr. Peale regards as Lower Tertiary. Buried, as this statement is, in the foot notes, it is easily overlooked, and the remark on the following page "that there was no marked action until the close of the Lignitic," in connection with the context, readily appears to contradict the quotation from my report on page 179. But there is no difference between Dr. Peale and myself. When I wrote that chapter in 1874 I regarded the whole Lignitic group as forming the closing portion of the Cretaceous. So I considered the period of accelerated upheaval as occurring at the close of the Cretaceous, that is, at the close of the Lignitic group. Dr. Peale places the action at the same time.

I have no additional facts to offer in support of the provisional conclusions which I offered in the report to Lieut. Wheeler. All the material in my possession is given in that report, and the synopsis of that, which seemed to have a bearing on the age of the system, is to be found in Wheeler, vol. iii, Chap. XVII. Nor am I likely to secure any additional facts either *pro* or *con*, as there is no probability that I shall have an opportunity to revisit the Rocky Mountains for a number of years.

New York, March 9th, 1877.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Velocity of Chemical Reactions.*—**Boguski** and **Kajander** have continued the experiments commenced by the former to ascertain the velocity of chemical reactions. Boguski defines velocity of reaction by supposing that $u=f(a_1, a_2, a_3, \ldots\ldots a_n, t)$, in which u is the quantity of the new body produced in the time t, and $a_1, a_2, a_3 \ldots\ldots a_n$ the conditions under which the reaction takes place. Hence the first differential coefficient, $\frac{du}{dt}f=(a_1, a_2, a_3 \ldots a_n, t)$ represents the reaction-velocity under the conditions given. It remains to find the form of the functions u and $\frac{du}{dt}$. Since all the conditions must be exactly measurable and expressible in numbers, the author chose for experiment the action of liquids on solids, in which the only variables—the temperature being constant—are the surface of the solid acted on and the concentration of the solution. "Concentration" is used to express the value given by the formula $D.\frac{1}{M}.\frac{p}{100}$, in which D is the sp. gr. of the solution, p the percentage content of the body dissolved and M its molecular weight. Since the number of molecules of this body in a unit of volume of the solution is directly proportional to this value, if V represent the volume in c.c., the formula $V.D.\frac{1}{M}.\frac{p}{100}=y$ represents the concentration

used in the experiment. Two modes of stating the results are proposed: 1st, that the quantity of the new body formed in an infinitely short time is proportional to the concentration y at that time; or 2d, that this quantity is proportional to the number of molecules of the liquid which act upon a unit of surface of the solid. Taking the reaction between zinc and sulphuric acid, and assuming that a unit of zinc surface dips in a unit of volume of the acid, the first hypothesis is expressed by the differential equation $d[H_2]=kydt$, in which $d[H_2]$ expresses the quantity of hydrogen set free in the infinitely small time dt, and k is the proportional coefficient. Since 49 parts of H_2SO_4 are required to evolve 1 part of H, we have $[H_2]=-\frac{1}{49}[H_2SO_4]=-\frac{1}{49}y$. Differentiating, $d[H_2]=-\frac{1}{49}dy$. Equating with this the above expression for $d[H_2]$, we have $\frac{dy}{y}=-49kdt$. By integration between the limits y_t and y_0, the value of y_t can be obtained; and by substituting this value for y in the first equation given above, changing the signs and integrating between corresponding limits, $\int_0^{[H_2]}d[H_2]=ky_0\int_0^t e^{-\frac{1}{49}kt}dt$, there is obtained $[H_2]=\frac{1}{49}y_0(1-e^{-\frac{1}{49}kt})=\frac{1}{49}(y_0-y_t)$, from which $k=\frac{1}{t}\cdot\frac{1}{49}\cdot\frac{1}{M}$ comm. log. $\frac{y_0}{y_t}$. The experimental results with zinc and sulphuric acid not being uniform, the author took Carrara marble and hydrochloric acid, the marble parallelopipeds being accurately measured. From this the surface-area was calculated and also the volume of liquid required to give a unit of volume to each unit of marble surface. The concentration of the acid was determined volumetrically, giving y_0. The carefully weighed marble was placed in the acid for a known time, then removed. washed, dried and weighed; from the loss, the carbonic dioxide evolved and the acid consumed were determined, giving y_t. From these data, by the formula $t=\frac{73}{44}kM\log\frac{y_t}{y_0}$, the value of $\frac{73}{44}kM$, and consequently of k, was calculated. As a mean of 53 well agreeing experiments, the value of $\frac{73}{44}kM$ was found to be 0·01765, and of k 0·0444±0·003 at 20° and 760 mm. Since this value is constant, it follows that the first supposition represents a fact, and that the quantity of carbon dioxide gas evolved from marble in a definite moment of time is directly proportional to the concentration of the acid at that moment. In connection with Kajander, Boguski has now extended the investigation to other acids, using nitric and hydrobromic in the new experiments. They find the values $\frac{126}{44}kM$ and $\frac{162}{44}kM$ respectively 0·0175, and 0·0185, being sensibly the same as that above given; hence the coefficient k, for these three acids is inversely proportional to their molecular weights. From the equation $d[CO_2]=kydt$, we have the velocity of the reaction $v=\frac{d[CO_2]}{dt}=ky$. Consequently when different acids of the same concentration act upon marble, the velocity of evolution of carbon dioxide is inversely proportional to their molecular weights.—*Ber. Berl. Chem. Ges.*, ix, 1646, x, 34, Jan. 1877. G. F. B.

2. *On the Equivalence of Nitrogen.*—Ladenburg and Struve have sought to throw some light upon the equivalence of nitrogen by studying carefully and comparing directly the properties of triethylbenzylammonium chloride and iodide on the one hand, and those of benzyltriethylammonium chloride and iodide on the other. The former bodies were prepared directly by acting on triethylamine with benzyl chloride in a sealed tube at 100°. A white crystalline mass results, which is soluble in water, and is easily crystallized therefrom. The platinum double chloride crystallizes easily from hot water, and has the formula $(N(C_2H_5)_3 C_7H_7Cl)_2PtCl_4$. The iodide, obtained by the action of silver oxide and hydriodic acid on the chloride, when its solution is evaporated on the water-bath, is very readily decomposed, yielding irritating odors of benzyl iodide. The second bodies were obtained by acting on benzylamine with ethyl iodide at 130°. The platinum double chloride gave the formula $(NC_7H_7(C_2H_5)_3 Cl)_2PtCl_4$. When, however, aqueous solutions of benzyltriethylammonium iodide are evaporated on the water-bath no benzyl iodide is formed even when the evaporation is carried to dryness. This difference in the behavior of the two bodies leads the authors to regard them as isomeric and not identical. The same conclusion is drawn from the form of crystallization of the platinochlorides, one being apparently monoclinic, the other orthorhombic. From this it follows that the five bonds of nitrogen in ammonium chloride have not all the same value.—*Ber. Berl. Chem. Ges.*, x, 43, Jan. 1877. G. F. B

3. *Action of fuming Nitric acid on Coal Gas.*—Akestorides has studied the products obtained from coal gas by passing it through fuming nitric acid, until a brown layer separated and crystals began to appear. The heavy layer evolved on heating torrents of nitrogen tetroxide gas, and on adding water, a yellow nitro compound separated which was not examined. The crystals consisted of oxalic acid. The lighter fluid, which had the odor of nitrobenzene, consisted essentially of two nitro-compounds, one boiling at 205°, the other at 222°, being nitrobenzene and nitrotoluene. A small quantity of a third body, boiling about 300°, was obtained, probably a nitro-naphthalene. In examining for the source of the production of oxalic acid, the author found that benzene gave none when treated with fuming nitric acid, while toluene and xylene gave small quantities, and ethylene afforded it abundantly. Hence the author concludes, contrary to Berthelot's opinion, that ethylene is absorbed by nitric acid and is oxidized to oxalic acid; this substance being permanent even in fuming acid.—*J. pr. Ch.*, II, xv, 62, Jan. 1877. G. F. B.

4. *On oxidized Platinic sulphide.*—E. v. Meyer has examined the so-called oxidized platinic sulphide, long known for its special catalytic activity. It was prepared by precipitating a hot solu-

tion of potassium platino-chloride by hydrogen sulphide, washing the precipitate by decantation with hot water, and drying for several days on the water-bath, during which latter process the oxidation takes place. It appears as a heavy black powder, which on continuous heating at or above 100° suffers further oxidation. If the heating be rapid, oxygen is absorbed, sulphurous and sulphuric oxides are formed, and platinum is left. On examination it was found to contain the elements of water; and upon analysis two products were distinguished, one the normal hydrate $PtS\left\{\begin{matrix}OH\\OH\end{matrix}\right.$, the other derived from two molecules of this by the loss of water, $\left.\begin{matrix}PtS\\PtS\end{matrix}\right\}O\begin{matrix}OH\\OH\end{matrix}$. The analytical results for the latter were satisfactory; but the former could not be obtained as pure. The sulph-oxide $(PtS)O$ does not appear to exist free. The author finds the body to be an energetic oxidizer, H_2S yielding S, SO_2 giving SO_3, HCl evolving Cl, NH_3 producing HNO_2 and HNO_3, oxalic acid giving CO_2, ferrous being oxidized to ferric salts, alcohol to aldehyde and toluene yielding benzaldehyde.—*J. pr. Ch.*, II, xv, 1, Jan. 1877. G. F. B.

5. *Preparation of Glycollic acid by reduction of Oxalic acid.*—Crommydis has succeeded in producing glycollic acid from oxalic, by the action upon it of nascent hydrogen. The oxalic acid dissolved in water, was mixed with zinc turnings and heated for eight days in a water-bath. The liquid was then filtered, treated with milk of lime, again filtered, the excess of lime removed by oxalic acid, boiled to destroy the glyoxylate, again filtered, and evaporated to crystallization. On cooling, crystalline warty masses formed which were soft like wax, and which on analysis proved to be calcium glycollate, crystallized with four molecules of water. The copper and zinc salts were also prepared and examined.—*Bull. Soc. Ch.*, II, xxvii, 3, Jan. 1877. G. F. B.

6. *On the Decomposition of the Oil of Turpentine at high Temperatures.*—Schultz has studied the products of the action of high temperatures upon oil of turpentine, using iron tubes and heating them in a Hofmann furnace to a dull red heat. The oil distilled between 158° and 161°, and was caused to flow into the heated tube drop by drop. Carbon was deposited, combustible gases were evolved which were not examined, and a black tar collected in the well-cooled receiver connected with the apparatus. This tar was fractionated, and the fractions examined. The portion boiling below 200° afforded benzene, toluene and xylene; that below 300°, naphthalene; and that above 300°, phenanthrene, anthracene and methyl-anthracene.—*Ber. Berl. Chem. Ges.*, x, 113, Feb. 1877. G. F. B.

7. *Constituents of Beech-wood Tar-creosote.*—Tiemann and Mendelsohn have examined the properties of creosol and phlorol, constituents of that fraction of beech-tar creosote boiling near 220°. By the action of acetic oxide on potassium-creosol, acetyl-creosol is obtained, and this by oxidation and removal of the

acetyl, gives vanillic acid. Creosol is therefore parahydroxylmetamethoxyl-toluene. From phlorol, methyl-phlorol and oxyphthalic acid were prepared.—*Ber. Berl. Chem. Ges.*, x, 57, Jan. 1877. G. F. B.

8. *Measurement of High Pressures.*—M. L. CAILLETET has recently constructed a manometer capable of measuring high pressures, on the slope of a hill near his laboratory at Chatillon-sur-Seine. The apparatus consists of a metallic tube 70 meters long and about 2 mms. interior diameter. One of the extremities of this tube is soldered to a reservoir of iron filled with mercury and placed at the base of the hill. To the free extremity of the tube a large glass tube is attached, which forms the upper end. When the mercury contained in the reservoir is compressed, it is forced up into the metallic tube so as partly to fill the glass tube, which is fixed on a vertical plate. This portion of the apparatus is movable, owing to the flexibility of the metallic tube and may be carried to one side and placed against either of several stakes arranged along the slope and having indices distant from each other exactly 760 mms. vertically. Fractions of an atmosphere are measured by a graduated scale resting against the stake. Attached thermometers give the correction for temperature. A pressure of thirty-four atmospheres may thus be obtained. M. Cailletet proposes shortly to measure the compressibility of gases at very high pressures by the aid of the shaft of a deep mine. For this purpose it is only necessary to lower into the shaft to a known depth a cylindrical reservoir of iron about two meters long and containing the apparatus with gilt glass he previously used in testing the law of Mariotte. A small metal tube starting at the surface is attached to the iron reservoir. When mercury is turned into the extremity of the metallic tube, it descends into the reservoir and produces a pressure which is transmitted to the gas in the interior. This pressure is accurately measured by the difference of level of the mercury in the two tubes. Thus with no special apparatus and simply by the aid of mercury we can compress a gas several hundred atmospheres and at the same time measure exactly the pressure produced.—*Comptes Rendus*, lxxxiv, 83. E. C. P.

9. *Diathermaneity of Metals and Paper.*—M. AYMONNET, from his own observations, together with those of Wiedemann and Franz, on the rapidity with which the equilibrium of temperature is established in bars whose coefficients of conductibility are sought, arrives at the following conclusions:

1st. That metals and paper are not athermanous as is generally supposed.

2d. That they are more diathermanous for the obscure rays emanating from metallic bodies brought to a temperature below 100° than for the luminous heat rays, or those near the red end of the spectrum.

3d. That they have absorbent powers less than that of water. The complement of the inverse ratio which exists between the quantity of heat which penetrates normally into a body and that which goes out of it in the same direction is here called the absorbent power.

4th. That it is possible to find a mathematical relation between the absorbent power of a body and its coefficient of conductibility. *Comptes Rendus*, lxxxiv, 259. E. C. P.

10. *Increase of Weight by Combustion.*—M. V. MEYER suggests a form of lecture-room experiment to show the increase of weight in the combustion of a substance at the expense of the oxygen of the air. Some years ago Professor Hoffmann showed a practical method of demonstrating experimentally the increase of weight of iron when burned in oxygen, but there has been as yet no simple means of proving this fact for objects like a candle, which appear to the eye to diminish. A candle is attached to each pan of a balance, and above one a glass tube open at both ends is hung, at nearly the height of the wick. In this tube is a piece of wire gauze holding some pieces of caustic soda; after balancing the candles, one of the candles is lit, when the products of combustion are retained by the soda and this end of the beam descends. At the end of a quarter of an hour the difference in weight may amount to three grams.—*Ber. Chem. Gesell.*, ix, 1866; *Bib. Univ.*, ccxxix, 106. E. C. P.

11. *Absorption of Light.*—M. LIPPICH of the Vienna Academy has recently been investigating the influence of the mean distance of absorbent particles upon absorption. As such an influence must be especially prominent when the substances afford well-defined absorption bands, and, with considerable density, show no strong colors, he chose for his experiments the nitrate of didymium oxide, which has these properties in a high degree. A pretty concentrated aqueous solution of this salt in a vessel one centimeter thick was spectroscopically compared with a solution having a concentration of only 0·1, 0·05 of the first. These solutions were in tubes of ten and twenty centimeters severally. A Steinhiel spectroscope was used, and the light sources were two gas lamps so regulated that both spectra showed the same brightness on the parts that were free from absorption. Even with the concentration ratio 1·10, there were marked differences in the absorption bands. The very characteristic bands in the yellow and yellow-green were, for the more concentrated solution, considerably broadened toward the red end of the spectrum, while the sharp limit toward the violet was the same for both solutions. The much narrower bands in the green showed quite a similar behavior. In the other parts differences were observed with difficulty. Besides this difference in the breadth of the absorption bands, there were others in the distribution of the bright parts.—*Nature*, xv, 208. E. C. P.

12. *Lippmann's Electrometer.*—Professor DEWAR exhibited to the Physical Society a simple electrometer which he has designed, founded on the discovery of Lippmann that the capillary constant is not really independent of the temperature or condition of the

surface, but is a function of the electromotive force. If a capillary tube be immersed in mercury, and dilute sulphuric acid be placed in the tube above the mercury, and a current from a Daniell's cell be so passed through the liquids that the mercury forms the negative pole, the column will be depressed to an extent dependent on the diameter of the tube. In making an electrometer, Professor Dewar has increased the sensitiveness by connecting two vessels of mercury by means of a horizontal glass tube filled with the metal, except that it contains a bubble of dilute acid. The tube must have an internal diameter of two millimeters, and it is essential that it be perfectly clean, uniform in diameter and horizontal. The instruments exhibited were constructed by Messrs. Tisley and Spiller, and Professor Dewar showed that it is possible by means of them to measure an electromotive force equal to $\frac{1}{10000}$ of a Daniell's cell; forces capable of decomposing water must be measured by causing two currents to act against each other. The index bubble is brought to zero by uniting the mercury cups by a wire. The apparatus is very convenient, as it requires no preparation and is extremely simple in its action. He next showed an instrument arranged by Mr. Tisley for producing a current by the dropping of mercury from a small orifice into dilute sulphuric acid; if the vessels containing the mercury and the acid be connected by a wire a current is found to traverse it. He then exhibited a manometer suitable for measuring very slight variations of pressure, and he illustrated the use of it for proving Laplace's law that the internal pressure multiplied by the diameter of a soap bubble is constant. It consists of a U-tube one arm of which is about fifteen inches long and is bent horizontally and levelled with great care. If the shorter arm be connected with a tube on which a bubble has been blown and the diameter of the bubble be varied, the position of the extremity of the alcohol column will be found to vary in accordance with the above law.—*Nature*, xv, 210.

E. C. P.

13. *Entwickelung der theoretischen Ansichten über die gepaarten Schwefelverbindungen;* von GEO. A. SMYTH (of Amherst Mass.). 122 pp. 8vo. Berlin, 1876.—In the above titled Monograph the author has endeavored to give a critical, historical sketch of the theoretical views concerning the large and important family of organic-inorganic bodies, which may be appropriately designated as the *conjugated* or *copulated* compounds of sulphur, and which comprises the classes of *sulpho- sulphi-* and *hyposulphi-* acids, the *sulphohydrates* or *mercaptanes*, and their derivatives. Beginning with the discovery of the first organic derivatives of H_2SO_4 through the experiments of Dabit, Sertürner, Vogel, Gay-Lussac, Hennell and Faraday, and the formation of the first sulpho-compounds by Faraday and others, in the early part of this century, it discusses in successive chapters the older modes of viewing these bodies by Faraday, Magnus, Liebig, Regnault, Berzelius, Mitscherlich, and Fehling, the views of the originators of the theory of substitution, those of the followers of the electro-chemical

radical theory up to the time of Kolbe's modification of this theory, and the hypothesis of copulation, the further development by disciples of the radical theory in accordance with the *atomistic* conception of combination, the typical theory and the copulated compounds, the development of atomistic views of combination by the typicists, and the present modes of interpreting the copulated compounds. At the close a chapter is added describing briefly the discovery and the character of the different classes of the conjugated sulphur compounds, and more especially those of the sulpho-acids, their formation out of different groups of organic bodies, the number of sulpho-substitutions, their modes of formation, their metamorphoses through modifications of the inorganic group, and their decompositions by separation of the organic from the inorganic compound parts. In connection with this chapter some points of theoretic interest, such as the constitution of sulphurous acid, Kolbe's prognosis of sulpho-alcohols and aldehydes, etc., which could not be conveniently discussed in the main body of the work, are taken up.

After discussing the older modes of interpreting the sulpho-compounds, which were, from the insufficient data, necessarily crude, and which failed to give any systematic explanation of the action of H_2SO_4 upon organic bodies, the compounds being variously regarded as combinations of organic bases with sulphuric, hypo-sulphuric acid, etc., and after briefly sketching the rise of the theory of copulation, which was largely owing to the study of sulpho-acids, the author next treats of the development of the atomistic conception of combination by Kolbe and Frankland in the sixth decade, maintaining that we find here the first satisfactory explanation of the constitution of the copulated sulphur compounds, and the first conception of the sexivalence and consequently variable atomicity of sulphur. The reasons for Kolbe's explanation of the constitution of these bodies, as compounds of sexivalent sulphur having exerted so little influence, and of his claims to having established the hexavalence of sulphur, and also the quadrivalence of carbon having been so generally overlooked are sought for principally in his retention of equivalent formulæ, which could not express his own views of chemical combination, and which showed that his conception of atomicity, though broadly stated, was not defined with sufficient sharpness and definiteness.

Under the head of the typical theory in its relations to the copulated sulphur compounds, which is the subject next treated, the attention of the reader is directed to the influence of Gerhardt's discoveries of the sulpho-chlorides and amides, and Buckton's and Hofmann's preparation of numerous disulpho-acids, Gerhardt's comparison of the sulpho-compounds with the carbonic acid series as compounds containing the radicals SO_2 and CO respectively, Limpricht's and von Uslar's investigations of the sulpho-benzoic acid compounds, their view of the substitution of H in the organic radical by SO_2, Mendius' view of the typical formulæ as an expression of the constitution of chemical compounds, Kekule's mixed types, and the controversy between the champions of the typical theory, being the subjects most prominently taken up. The typical theory contributed, according to the view of the author, very little toward the advancement of our theoretic knowledge of the copulated sulphur compounds. It failed signally to throw light upon the peculiar nature of the sulpho-acids, it proved itself to be utterly unable, as the interpretations of Carius's investigations abundantly show, to explain any difference of constitution between the sulpho-acids and the metameric hypothetical primary ethers of sulphurous acid, while the adoption of complex multiple and mixed types showed the fruitlessness of all attempts to refer compounds capable of undergoing manifold reactions to any typical bodies. But an atomistic explanation of the copulated sulphur compounds presented peculiar difficulties to the disciples of the typical school, as it necessitated the acceptance of a higher atomicity of the sulphur atom, and accordingly it was not until the discovery of the true primary ethers of sulphurous acid, and of the isomeric phenole sulpho-acids, and furthermore of the difference in constitution of these acids from the primary acid ethers, that the typicists adopted an atomistic conception of combination.

After sketching the gradual development of atomistic and structural views by the former typicists, as shown most prominently in the attempts of Kekule to derive the copulated sulphur compounds from a dyad S, and in the adoption by Butlerow and Erlenmeyer of a higher atomicity for S, the author goes on to compare the views held at present with those advanced by Kolbe, endeavoring to show that the explanations of the chemical deportment of the sulpho-compounds now given are essentially the same as those given by Kolbe, some twenty years ago, that these chemists differ however from Kolbe in their general conception of the constitution of a body, and in their views as to the manner in which the S-atom is combined with the organic radical. The latter difference of opinion is, according to the author, the only essential one, and he, although assenting to Kolbe's general views as to the chemical constitution of a body, does not hesitate to accept Butlerow's definition of the sulpho-compounds, i. e. as compounds of a sexivalent S, in which the S is combined directly with a C-atom of the organic body.

II. GEOLOGY AND MINERALOGY.

1. *Note on the Age of the Crystalline Rocks of Wisconsin;* by ROLAND IRVING. (Communicated.)—In a note on the "Huronian of Canada," published in this journal for December last, Mr. A. R. C. Selwyn, criticising Mr. F. H. Bradley's reference of the Canada, Wisconsin, and Michigan Huronian to the Lower Silurian, uses the words: "If, however, it is an established fact that in Minnesota (Michigan?) and Wisconsin the same Huronian rocks are unconformably covered by the Potsdam sandstone . . . ." Such

an unconformability in Wisconsin is certainly a fact, established not by one or two instances, but by many. The exact junction between the two formations is often to be seen, the almost loose sand of the Potsdam, with numerous fossils, as also fragments derived from the older rocks, lying upon and wedged in between the tilted ledges of Huronian quartzite, schist, or other rock. Exactly similar unconformability is to be seen at the Dalles of the St. Croix River between the Potsdam and Copper series; the horizontal beds of the former, filled with shells of *Lingullella*, lying directly upon the columnar melaphyre (?) of the latter series, the exact junction of the two series being exposed. The crystalline rocks of Wisconsin include unquestionably two distinct terranes, the one lying unconformably upon the other, as is beautifully shown at Penokee Gap, on Bad river, in the Lake Superior country. Here a white siliceous marble of the Huronian, overlaid by hundreds of feet of distinctly bedded slaty rocks, and dipping northward, is to be seen within twenty feet of large ledges of dark colored amphibolic gneiss, whose bedding planes dip southward and strike in a direction diagonally across that of the more northern beds. There are no doubt instances where the two series are difficult to separate, similar rocks occuring in both groups, but the existence of the two is incontestable, and their unconformability with the unaltered Potsdam equally so. The facts *proven* thus far with regard to the older rock series of Wisconsin may be briefly summarized as follows: the oldest (I) are gneisses and granites with other rocks; these are overlaid unconformably by (II) a series of quartzites, schists, diorites, etc., with some gneiss and granite; these in turn are overlaid—probably also unconformably, but this is not certainly proven—by (III) the Copper series, which includes greenstones and melaphyres, and also great thicknesses of interstratified sandstone, melaphyres, amygdaloids and shales, the whole having a thickness of several miles; these finally are unconformably covered by (IV) a series of unaltered horizontal sandstones including numerous fossils, many of which are closely allied to those of the Potsdam sandstone of New York, and all of which have a marked Primordial aspect. I and II are referred to the Laurentian and Huronian systems of Canada, because they bear the same relations to one another and to the Copper series that these systems do. However this may be, it will be seen that in order to include the Wisconsin crystalline rocks within the Silurian, Mr. Bradley would have to stretch that term so as to cover three entirely distinct terranes, each overlying its predecessor unconformably and many thousand feet in thickness, the highest of the three in its turn overlaid unconformably by horizontal sandstone with Primordial fossils. As to any of the Wisconsin or Michigan crystalline rocks being altered equivalents of the Primordial and newer strata of the eastern States, such an hypothesis is certainly untenable for a moment. Such things may and in all probability do occur in the Appalachians, but there certainly has been no period of metamorphism in the region of the northwestern States since the beginning of the Primordial.

University of Wisconsin, March 8th, 1877.

2. *Microscopical Petrography;* by FERDINAND ZIRKEL. Being Volume VI of the series of Reports of the U. S. Geological Exploration of the 40th Parallel, CLARENCE KING, Geologist-in-charge. Submitted to the Chief of Engineers, and published by order of the Secretary of War under authority of Congress. 298 pp. 4to, with twelve plates. Washington, 1876.—The great region west of the Front Range of the Rocky Mountains, including the part in the vicinity of the 40th Parallel, abounds in igneous rocks, from dolerytes to trachytes and related kinds, some of them closely like rocks of central and southeastern Europe; and Mr. King has done well in looking to Europe for the study and description of his specimens, and has been most fortunate in securing the labors of Prof. Zirkel, the leading author in microscopic lithology. The results are therefore excellent, and at the same time they give to the American student the present European use of the names of rocks.

The Report commences with an Introduction reviewing the kinds of crystalline rocks and their microscopic distinctions. In this chapter Prof. Zirkel states that in his descriptions he uses the term "ground-mass" for the mass of a rock where it is distinctly crystalline granular under the microscope, and "base" when there is an amorphous paste not crystalline granular under the highest magnifying power, though containing, except in many obsidians, crystalline minerals.

He remarks also on the evidence that the crystalline minerals in the "base" were formed while the latter still had a flowing movement, as shown by the minerals ranging in straight or wavy lines, and by their fractures and abrupt bends or displacements; hence the positions and forms of the crystals have been partly determined by the flowing; and hence, also, the rock has not undergone any metamorphic changes since solidification took place. Those rocks whose micro-fluidal structure is particularly distinct are generally proportionally rich in broken crystals shivered into detached sharply angular fragments.

The feldspar-bearing igneous rocks he divides as follows:

I. The FELDSPAR ORTHOCLASE.—(*a.*) *Containing quartz or an excess of silica:* granite, granite-porphyry, felsite-porphyry, rhyolyte, obsidian, pearlyte, pumice, pitchstone.—(*b.*) *Containing no quartz, and often with more or less plagioclase feldspar:* syenyte, augite-syenyte, quartzless orthoclase-porphyry, trachyte, augite-trachyte.—(*c.*) *Containing no quartz, and with more or less nephelite or leucite:* Foyayte, miascyte, orthoclase-porphyry, phonolyte (containing nephelite), and leucite and sanidin rocks.

II. The FELDSPAR OF THE PLAGIOCLASE OR TRICLINIC SERIES.—(*a.*) *Containing hornblende:* quartz-dioryte, dioryte, porphyryte, hornblende-porphyry, propylyte, quartz-propylyte, hornblende-andesyte, and dacyte.—(*b.*) *Containing biotite:* mica-dioryte.—(*c.*)

Containing augite: diabase, augite-porphyry, melaphyre, augite-andesyte, feldspar-basalt (including doleryte and anamesyte), and tachylyte.—(*d.*) *Containing diallage:* gabbro.—(*e.*) *Containing hypersthene:* hypersthenyte.—(*f.*) *Containing olivine:* (serpentine) "forellenstein."

III. Containing NEPHELITE as the feldspar mineral.—Nephelinyte and nepheline-basalt.

IV. Containing LEUCITE as the feldspar mineral.—Sanidin-leucite rocks and leucite-basalt.*

To understand this list it is necessary to have in mind some points in German usage connected with the naming of rocks. First, as to the affix, *porphyry.* It is not, as might be inferred, the name of a natural group or family of rocks, but, as the list shows, it is applied to rocks of various groups. It signifies really a *porphyritic variety* of some kind of rock. Felsite-porphyry is a porphyritic felsite (typical porphyry); granite-porphyry is a porphyritic granite, though restricted by Zirkel to a kind in which the granite is of very fine grain, between ordinary granite and felsite. So in cases, not above particularized, diabase-porphyry is a porphyritic diabase, dioryte-porphyry, a porphyritic dioryte, and so on. Again, the affix is used where the disseminated crystals are not feldspar, but some other mineral: thus, hornblende-porphyry, as used by Zirkel, is a gray hornblendic rock in which the large disseminated crystals are hornblende; and augite-porphyry, one in which the crystals are augite. The science would be better off without the word, except as used in the adjective form.

Further: syenite of the Germans is a rock consisting of hornblende and orthoclase *without* quartz, unlike the rock of Syene, Egypt, which originated the name. Syenite containing quartz as a prominent constituent is made a variety of granite—although having its nearest relations to other hornblendic rocks; and, if not made the typical syenite, entitled, by usage elsewhere in the above list, to the name *quartz-syenite.*

Again, the names of some kinds of rocks are made to depend on their geological age—an igneous rock if of Tertiary age having one name, and if older than Tertiary, another. Thus, labradorite and augite along with more or less magnetite make together a rock which is called *basalt* or *doleryte* if Tertiary or younger, and *diabase* if of earlier date. It is a method of naming which might multiply names indefinitely, and which has nothing to commend it. It is to be noted also that Zirkel uses the name basalt in place of doleryte. Both basalt and diabase are described as often containing *viridite* or a hydrous chloritic mineral. The term melaphyre is restricted to an amygdaloidal basalt—an application not always easily made, since the same dike or mass of rock is often amygdaloidal in one small part and not through the rest of the mass, and there is an indefinite gradation between such melaphyre and the chloritic basalt. Peridotyte, or basalt containing olivine, is left as a variety of basalt.

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* The *y*, in the last syllable of the names of many of the rocks, is inserted by the writer.

Of the above mentioned rocks, those found in western America include, under I, granite and granite-porphyry, felsite-porphyry, syenite; under II, dioryte, hornblende-porphyry, propylyte, quartz-propylyte, hornblende-andesyte, dacyte, trachyte, rhyolyte, diabase, melaphyre, gabbro, augite-andesyte, basalt; under IV, leucite rock.

The volume is chiefly devoted to the description of these rocks from different localities, after a study of microscopic sections, and comparisons with similar rocks of other countries; and numerous very singular and interesting facts are brought out, besides important illustrations of the relations and mode of origin of the rocks. We add some notes respecting them, following the order in this list.

Propylyte is the most prominent rock of the Washoe district, Nevada, constituting the entire Virginia range. It is a grayish-green rock, consisting mostly of a plagioclase or triclinic feldspar, in small crystals or grains, and hornblende, the latter disseminated in minute points or crystals through the former, and often in part changed to chlorite or epidote. Apatite is sometimes present, and occasionally biotite. In mineral constitution it is scarcely distinct from dioryte, the silica, according to the analyses given, amounting to 64 to 66 per cent. It is of Tertiary age, and hence it is not called dioryte; but, in addition, it has generally more of the aspect of a modern igneous rock. A quartziferous variety is the *quartz-propylyte*.

Andesyte has, according to Zirkel, the constitution essentially of propylyte, that is, it consists mainly of a plagioclase feldspar and hornblende; and the physical differences drawn out on page 133—such as a purer gray color, the hornblende in coarser crystallizations, etc.—are feeble in kind and degree. The analyses, however, give it about 60 or 61 per cent of silica, and this would make the feldspar of the rock to contain four to five per cent less of silica. Andesyte, moreover, has sometimes a pasty or semi-glassy ground-mass. It occurs with the propylyte at various localities.

Dacyte is a *quartz-andesyte*, and this variety also occurs at Washoe and elsewhere. The color varies from light gray to dark blackish-brewn. The ground-mass is often rhyolitic and sometimes spherulitic, and thus differs from that of andesyte and propylyte. The analyses show that the feldspar contains relatively little lime, and therefore must be, in the main, andesyte or oligoclase. The quartz, unlike that of quartz-propylyte, shows no fluid-inclusions when microscopically examined.

Trachyte is described as occurring in the vicinity of Washoe, and between there and Pyramid Lake. The rock consists of sanidin or glassy orthoclase, but part of it—the older—contains a plagioclase feldspar also, and thus graduates toward andesyte. Tridymite was observed in the younger trachyte in thin 6-sided plates grouped together in great numbers. A "half-glassy-looking rock" from the Cow Hills, between Sheep Corral Cañon and Wadsworth, of dark brownish-black color, containing sanidin, and also pale green augite with some plagioclase feldspar and hornblende, is called an *augite-trachyte.* It resembles in general composition the augite-syenyte of vom Rath, which constitutes the larger part of Mt. Monzoni in the South Tyrol. Other localities are mentioned of trachyte and of this augite-trachyte.

Rhyolyte was so named by Richthofen in 1860. It was made to include certain trachyte-like or felsitic and more or less glassy rocks which contained disseminated quartz, and bore "clearer evidence than other rocks of having once flowed in a viscous state." The more or less glassy kinds comprise obsidian, pearlstone, and pumice. These Zirkel designates *glassy rhyolyte.* Other kinds, felsitic and sometimes porphyritic, not appearing glassy, but showing a fluidal structure in having the ingredients arranged in parallel wavy bands, instead of even-grained, as seen in microscopic sections, he designates *proper rhyolyte;* and certain granite-like kinds (not observed among the rocks of the 40th parallel) he calls *nevadyte.* Rhyolyte is found at several places in Nevada, and many varieties are particularly described and figured. They sometimes contain disseminated quartz crystals or grains as large as peas. In some the structure is fine granular throughout; in others, there are glassy lines or patches; in others, spherulites; and some are glassy throughout.

Augite-andesyte contains over 58 per cent of silica—in this differing from most igneous augitic or pyroxene rocks. A variety from west of Basalt Creek, Washoe, is brownish-black, somewhat resinous in luster, with "white feldspar crystals which are seldom tabular," and contains hyalite in its amygdaloidal cavities and fissures. The base is partly glassy. The feldspar is partly orthoclase (sanidin) in twins, and partly a triclinic species, the latter predominating. The percentage of silica was found to be 58·015. The same rock has been observed on Teneriffe, Java, Chimborazo, in Hungary, etc. Augite-andesyte is near the melaphyre of some lithologists, but differs in the base being partly glassy. It shows its relation to basalt by containing some chrysolite. The rock also occurs red, blackish, and of other colors.

Basalt is described from various localities. In a variety from Kawsoh Mountains, having a structure "intermediate between the micro-porphyritic and the even-grained," microscopic aggregations of tridymite crystals were observed, in the form of thin hexagonal plates, partly overlapping like tiles and partly in groups. This is the first time tridymite has been met with in basalt; and it is remarked that "since the basalt comes to the surface through or near strata of infusorial silica, it is not impossible, as Mr. Clarence King has suggested, that an included fragment of this silica may be the source of the tridymite, in which case it would of course be a substance originally foreign to basalt."

Leucite rocks are described from the Leucite Hills, northwest of Point of Rocks, Wyoming Territory. They are light yellowish-gray felsite-like rocks, very rich in leucite crystals, and containing augite in grains yet sparingly, with no feldspar of any kind. They thus differ widely from the European leucite rocks.

We here leave the volume. It is a rich treasury of facts respecting American and other igneous rocks, and merits thorough study in every part by those who would fully understand their nature and relation. J. D. D.

3. *Note upon the Connecticut Valley Helderberg;* by C. H. HITCHCOCK. (Communicated.)—At the close of an article upon Helderberg rocks in New Hampshire (this Journ., III, vol. vii, p. 571), I proposed to discuss later the relations of the Bernardston, Mass., Helderberg limestone to the associated rocks in Hinsdale, N. H., and Vernon, Vt. This has been done fully in the second volume of the Geology of New Hampshire, which will be accessible to the public next June. I desire now very briefly to state my principal conclusions. 1. The associated quartzite and staurolite mica slates have been satisfactorily traced out to connect with the Coös group of New Hampshire, as was first suggested by Prof. Dana (this Journ., III, vol. vi, p. 339). 2. The limestone does not certainly dip beneath the quartzite. Had the section been drawn a few rods north the slates would be found to dip west and the quartzite standing on edge and the limestone concealed by soil. On the west side of the limestone is a west dip in the quartzite. These facts suggest the possibility of a different interpretation from that heretofore universally given. The limestone may be a remnant of a once extensive deposit covering both the other formations mentioned, and what remains is in an inverted position. The limestone in Littleton overlies the quartzite. 3. If the Coös and Helderberg strata are identical in age, the hornblende schist near by and the gneiss of Vernon are not necessarily associated with them, nor any of the great gneissic areas of New England. The Coös slates unconformably overlie the clay slates (Lower Silurian or Cambrian) of West Mountain and its continuation northward, as first suggested by Prof. Dana. These same slates rest upon the Quebec group of Logan in the Littleton region, and these in their turn upon the same gneissic group as in Vernon. 4. Next to the Helderberg the Coös rocks are the newest in the Connecticut valley all the way to Canada; and if they can be proved identical with each other, and also to include the enormous calcareous area of Eastern Vermont and Canada, called "Calciferous mica-schist" in the Vermont Report, they show that all the rest of the northern New England formations are older, and hence liable to be of any Eozoic series. 5. The Bernardston region abounds with examples of inversions of the strata. It is impossible to propound any consistent theory of structure here without them. The same is true for the whole of New Hampshire. 6. Further search in the Littleton region enables me to correct the statement of my previous article. I am satisfied that all the clay slates of Littleton are of the same age with those of West Mountain; hence at least three-fourths of the area marked Helderberg on my map (p. 471), must be transferred to the other series. 7. The kinds and order of the Helderberg rocks are essentially alike in the Littleton and Bernardston fields; hence, by comparing the facts in both regions better

results are obtained than by reliance upon short sections in either one by itself.

Hanover, N. H., March 16, 1877.

4. *On Geological Time;* by T. Mellard Reade. Presidential Address before the Liverpool Geological Society. 28 pp. 8vo. Liverpool, 1877.—In this paper, Mr. Reade has used the analyses of river waters to determine the amount of mineral matter carried in solution from the land. He finds that the amount of water run off the area of England and Wales annually is 68,450,936,960 tons, equal to 18·3 inches in depth out of 31·988 inches of mean rainfall, leaving 13·7 inches for evaporation. The amount of solids in solution is 8,370,630 tons, or 12·23 parts in every 100,000 of water:—in which are about 9·50 parts of carbonate and sulphate of lime and magnesia, 1·66 of chloride of sodium, 0·08 of nitrates and 0·99 of alkaline sulphates and carbonate of soda, silica and sesquioxide of iron. Estimating the solids in solution at 15 cubic feet to the ton, the amount of denudation by solution would be ·0077 feet per century, or one foot in 12,978 years. Prestwich arrived at one foot in 13,200 years, for the amount of carbonate of lime which the Thames carries off from the Chalk, Upper Greensand, Oolitic strata and Marlstone. The Thames, estimating the discharge at 8 in. per annum, and the total solids at 29·26, as given by Prestwich, removes 147 tons per square mile per annum; and the denudation over England 143·5 tons.

Mr. Reade makes similar calculations for the rivers of Europe, and finds that the Rhine removes about 92·3 tons per square mile; the Rhone about 232 tons; the Danube about 72·7 tons; giving an average for the three rivers of 90 tons per square mile. The Garonne removes 142 tons per square mile; the Seine about 97 tons. From these data the conclusion is reached that probably over the world about 100 tons of rocky matter are dissolved by rain per English square mile per annum: of which, as near as can now be estimated, 50 tons may be carbonate of lime, 20 tons sulphate of lime, 7 silica, 4 each carbonate and sulphate of magnesia, chloride of sodium, and 6 alkaline carbonates and sulphates.

The amount of detritus brought down annually by the Danube is about $\frac{1}{3000}$ of the water, or three times the calculated amount of solids in solution; that of the Mississippi, according to Humphreys and Abbott, $\frac{1}{1321}$ of the water. Mr. Reade adds:

"If we were to take the solids removed mechanically at six times those in solution, which is a very high estimate, we should have over the whole of the globe 600 tons of denuded matter annually per square mile. Taking the sedimentary crust of the earth at ten miles thick throughout—a moderate estimate—and allowing for the denudation of the sea and the amount added to sediments by volcanic ejections, matter equal to one-third that which is denuded from the land, we should have annually removed and deposited matter equal to 800 tons per square mile of land surface, or 40,800 million tons annually. The total surface of the globe is 197 millions of English square miles. A cubic mile of rock at 13½ feet to the ton would weigh 10,903,552,000 tons, so that to cover the whole surface of the globe one mile deep with sediment from the land at the rate of 800 tons per square mile of land surface, would take 52,647,052 years, or 526 million years in round numbers for ten miles deep."

5. *The Carboniferous and Permian a continuous formation in Bohemia.*—A paper full of details as to fossils is published by Dr. Feistmantel in the Geological Magazine for March, in which the author proves that "in Bohemia (certainly also in other localities) there is no strict boundary between the Carboniferous and Permian; on the contrary, that these formations are in very close connection, as is shown in the association of a flora of Carboniferous character with animals mostly of Permian character, in the Gas-coals of the Pilsen and Kladno-Rakonitz basins." In the Pilsen coal-basin the gas-coal contains the Permian animal fossils, *Xenacanthus Decheni*, "one of the best Permian species," an *Acanthodes* near *A. gracilis* Röm., a *Palæoniscus*, *Uronectes* (*Gampsonyx*) and other species; and there are among fossil plants, *Lepidodendron dichotomum* Stbg., *Sagenaria elegans* Stbg., *Knorria*, *Lepidophyllum majus* Brgnt., *Sigillaria distans* Stbg., species of *Cyclopteris*, *Odontopteris*, *Neuropteris*, about nine Carboniferous species of *Sphenopteris*, four Carboniferous species of *Cyatheites*, three of *Alethopteris*, etc. Similar facts are reported from the other district referred to.

6. *Revue de Géologie pour les Années* 1874–1875, Vol. XIII; by M. DELESSE, Ingenieur-en-Chef des Mines, et M. de LAPPARENT, Ingenieur des Mines, Prof. Geol. 252 pp. 8vo, with a colored agricultural chart of France showing its agricultural products, by M. Delesse. 1877.—From this valuable Geological Annual, bringing up the review of geological memoirs and discoveries to the middle of 1875, we cite the following:

Feldspathic rocks under the solvent action of water, carbonated waters and other reagents in solution.—M. Truchot subjected a series of Auvergne rocks in powder for several days to water charged with carbonic acid under a pressure of eight atmospheres, and obtained the following percentage results:

	Whole am't dissolved.	CaO removed.	K_2O removed.	P_2O_5 removed.
Granite of Montaigui.........	0·80	---	0·10	---
Granite of Trezioux..........	0·90	---	0·09	---
Lava of Volvic...............	1·75	0·25	0·08	trace
Domite, Puy de Dome........	1·82	tr.	0·06	tr.
Trachyte of Mt. Dore	2·90	tr.	0·18	tr.

The trachyte was most readily attacked, especially its silica, and this accounts for the frequent occurrence of opal and other siliceous deposits in the fissures of this rock.

M. Cona, exposing the syenite of Bielle, finely pulverized, to water, dissolved 0·18 per cent at the ordinary temperature, and 0·42 at 100° C.; to water saturated with CO_2, dissolved 0·63 per cent; to water saturated with sulphate of lime, 0·43 per cent.

Orthoclase feldspar has been exposed to different solutions by A. Beyer, aided by Birner, Ulbricht and Heinrich (Arch. Pharm. II, cl, 193). A kilogram finely pulverized was put each time in two liters and a half of water or certain solutions, and kept so for about five months—out of contact with the air. The weight in grams dissolved in the 2½ liters of water for the different liquids was as follows:

	Equiv.	K_2O	Na_2O	CaO	MgO	F̶e, A̶l	SiO_2
Distilled water........	..	0·051	0·078	0·058	0·006	....	0·049
Carbonic acid in water	..	0·071	0·114	0·076	0·004	0·009	0·069
Lime	0·1	0·209	0·174	0·067	0·003	0·008	0·061
Magnesia	1·0	0·359	0·315	0·013	0·004	....	0·159
Magnesia and CO_2 ...	1·0	0·312	0·255	tr.	0·569	...	0·048
Gypsum	0·2	0·053	0·074	1·906	0·016	....	0·033
Sulphate of ammonium	0·2	0·161	0·094	0·122	0·035	....	0·066
Chloride of sodium...	0·2	0·163	....	0·091	0·008	0·004	0·032

The results are of much interest, showing that common salt and sulphate of ammonium, products that are usually in the soil, increase much the dissolving power of water; and still more do lime and magnesia—these bases separating the alkalies. Lemberg has shown that by the action of sulphate of magnesia on the zeolites, operating in closed tubes with heat, they were changed to hydrous silicates of magnesia; apophyllite being thus changed, losing in the process all but a few hundredths of its lime. Such facts are of great interest in connection with the subject of the origin of serpentine pseudomorphs.

7. *A fossil Saurian Vertebra from the Arctic Regions.*—Prof. A. LEITH ADAMS has named the Saurian, a vertebra of which was brought from Rendezvous Point, Byam Martin Channel, by Admiral Sherard Osborn, *Arctosaurus Osborni.* It is "in all probability one of the middle cervicals of a Saurian with biconcave vertebræ," between ten and twelve feet long, agreeing "better with Lacertilia than Crocodilia." Sir Edward Belcher, Sir L. McClintoc, and Admiral Osborn brought many fossils from the group of islands lying between North Cornwall and North Devon. Among others were remains of Ichthyosaurus, determined by Prof. Owen, and said to be from Lias beds; and these are the only Arctic Reptilian remains hitherto described.

8. *Fossil Vertebrates from the Fort Union beds of Montana.*—Prof. E. D. COPE has described the following species in the Proceedings of the Philadelphia Academy of Natural Sciences, for 1876, p. 248: *Aublysodon lateralis*, *Lælaps incrassatus*, *L. explanatus*, *L. falculus*, *Dysganus encaustus* (a herbivorous Dinosaur), *D. Haydenianus*, *D. bicarinatus*, *D. peiganus*, *Diclonius pentagonus* (allied to *Hadrosaurus*), *D. perangulatus*, *D. calmarius*, *Monoclonius crassus* (near *Hadrosaurus*), *Paronychodon lacustris* (near *Plesiosaurus*), all based on specimens of teeth; also *Compsemys imbricarius*, *C. variolosus*, *Polythorax Missuriensis*, *Hedronchus Sternbergii*, *Ceratodus cruciferus*, *C. hieroglyphus*, *Myledaphus bipartitus*.

9. *A Text-book of Mineralogy, with an extended Treatise on Crystallography and Physical Mineralogy;* by EDWARD SALISBURY DANA, Curator in Mineralogy, Yale College. On the plan and with the coöperation of Prof. JAMES D. DANA. 486 pp. large 8vo, with over 800 wood-cuts and a colored plate. New York, 1877. (John Wiley & Sons, 15 Astor Place).—This work is intended for a class-book in the science. One half is occupied with the subjects of Crystallography, Physical Mineralogy, and Chemical and Determinative Mineralogy, and the other half with the Descriptions of species and a Catalogue of American localities. The subjects of crystallography and optical mineralogy are treated at much length in order that the student may have at hand the means of acquiring the special knowledge demanded for complete investigations; and illustrations and descriptions of the best instruments are given for the same purpose, besides numerous diagrams and figures of crystals. About seventy pages are devoted to descriptive crystallography, over twenty to mathematical crystallography after Nauman's system, and as many more to the same after Miller's system, each of which subjects is very fully illustrated by figures; and the chapter on optical characters extends to thirty-five pages. Besides, there are lists of recent works and memoirs on the various subjects considered under Physical Mineralogy.

The Descriptive part of the volume follows in its classification essentially that of the last edition of the system of Mineralogy, and is, in the main, a condensation of that work. But all new species introduced since the date of its publication have been inserted. The more important species—about half of all known—are described at length (though with few analyses, and often only the percentage composition), and the rest more briefly.

The preparation of this text-book, as the Preface states, was begun by Professor Dana shortly after the appearance of his larger work. But it was interrupted before the crystallographic part was completed; and in that state it has remained until taken up within the year past by Mr. Edward S. Dana. To Mr. Dana is due a revision of the crystallographic chapter, with some important modifications, the chapter on Miller's System, the section on Optical mineralogy, the notes on all new species, and a general review of the whole subject, bringing in results from recent publications.

For the full synonymy of the mineral species and the history of that synonymy, extended descriptions of American and foreign localities, tables of the many chemical analyses of minerals that have been made from the earliest times, notes on the alterations of minerals and occurring pseudomorphs, and some other points the reader will still have to look to the System of Mineralogy and its Supplements.

10. *Second Preliminary Report on the Mineralogy of Pennsylvania*, by F. A. GENTH; with analyses of mineral-spring waters. Harrisburg, 1876.—This is a report of progress, embodying the

work done upon the mineralogy of Pennsylvania during the year 1875. It contains a considerable number of new analyses, mostly of minerals, also of rocks, mineral waters and natural gases. Among other points Dr. Genth shows that the "*melanosiderite*" of Cooke is "not a good species, but simply an impure variety of hydrated iron sesquioxide, probably limonite." The "*cassinite*" from Blue Hill, Delaware Co., described by Lea as a variety of orthoclase, is shown to contain 3·7 p. c. baryta; the mean of three analyses gave: Silica 62·60, alumina 19·97, iron sesquioxide 0·12, magnesia 0·02, lime 0·19, strontia, tr., baryta 3·71, soda 4·43, potash 9·00, ignition 0·19=100·23. Specific gravity 2·692. E. S. D.

11. *Brief Notices of some newly described minerals. Ludlamite.*—Occurs in small monoclinic crystals, with distinct basal cleavage. Hardness 3·4. Specific gravity 3·12. Color clear green; transparent. Its composition is expressed by the formula $2Fe_3P_2O_8+H_2FeO_2+8aq$, which requires: Phosphorus pentoxide 29·88, iron protoxide 53·06, water 17·06=100. The formula of vivianite, to which it is related, is $Fe_3P_2O_8+8aq$. Ludlamite occurs in some of the mines of Cornwall, England, associated with vivianite, siderite, pyrite, arsenopyrite, etc.—(*Field*, *Phil. Mag.*, Jan., 1877.)

Strengite.—Occurs usually in spherical incrustations with a radiated structure, and a drusy surface; also rarely in orthorhombic crystals of tabular form. Hardness 3–4. Specific gravity 2·87. Color white, in some varieties bright carmine-red, in crystals also colorless. Transparent to translucent. Composition expressed by the formula $\overset{\cdots}{F}eP_2O_8+4aq$, which requires: Phosphorus pentoxide 37·97, iron sesquioxide 42·78, water 19·25=100. In form and composition it is allied to scorodite ($FeAs_2O_8+4aq$). Strengite is found with cacoxenite at the iron mine Eleonore near Giessen.—(*Nies*, *Jahrb. Min.*, 1877, 8.)

Pelagite.—The name *pelagite* is given provisionally by Prof. A. H. Church to the material constituting the "manganese nodules" obtained by the Challenger in deep-sea soundings in the Pacific. An analysis afforded the following results: Manganese dioxide 30·22, iron sesquioxide 20·02, alumina 3·30, silica 10·37, chlorine 0·71, Mg, Ca, Na, etc., 0·83, water lost below 100° 24·55, lost at a red heat 10·00=100. It will be seen that the nodules, if homogeneous, have a complex chemical composition, and by no means consist essentially of "nearly pure peroxide of manganese," as had been reported. As stated by Prof. Church, the further analysis of additional material is needed before the name *pelagite* can be fairly accepted.—(*Church*, *Mineralogical Magazine*, No. 2, p. 50, Nov., 1876.)

Lawrencite.—M. Daubrée has given the name *lawrencite* to the protochloride of iron, the presence of which he has detected in the Greenland meteoric iron. It was earlier separated by Dr. J. Lawrence Smith from the Tennessee meteoric iron, and the name is given in honor of him.—(*C. R.*, Jan., 1877.)

Hydrocastorite.—G. Grattarola of Florence has observed a white mealy material surrounding the castorite of Elba, and he makes it a new mineral under the name hydrocastorite, it having been derived from the decomposition of castorite. It is in part compact, in part it is made up of an aggregate of fine needle-like crystals. Its composition is shown by the analysis: Silica 59·59, alumina 21·35, lime 4·38, water 14·66=99·98.

Guanajuatite.—The sulpho-selenide of bismuth from Guanajuato, Mexico, partially described by Castillo, (1873), and later fully described by Frenzel (Jahrb. Min., 1874, 679), was named *frenzelite* in the Second Appendix to Dana's Mineralogy (1875, p. 22). It seems, however, that the same mineral was at first named *guanajuatite* by Fernandez, who described it in full in the Guanajuato paper, "La República" for July 13th, 1873. The latter name should consequently be accepted instead of the name *frenzelite.* The description by Professor Fernandez differs from that of others in that he makes the mineral solely a bismuth selenide (Bi_2Se_3), and attributes the presence of a small amount of sulphur, shown in his analyses, to the admixture with a little pyrite. The material analyzed by Frenzel received the formula $2Bi_2Se_3+Bi_2S_3$.

Silaonite.—In the paper, "La República," for Dec. 23d, 1873, Professor Fernandez describes a second bismuth selenide from the same locality, the Santa Catarina mine at Guanajuato. It has a lead-gray color, and is compact in structure. Its hardness is a little less than that of calcite; its specific gravity 6·428—6·45. The results of several analyses upon material more or less pure led to the conclusion that the chemical composition is expressed by the formula Bi_3Se. E. S. D.

12. *Zeitschrift für Krystallographie und Mineralogie;* vol. i, No. 1, 1877.—The first number of this new Journal, recently received, admirably fulfills the promises made in the Prospectus. (See p. 162 of this volume.) It contains the following original articles: Mineralogical contributions by G. vom Rath; description of some immense enstatite crystals from Bamle, Norway, by W. C. Brögger and G. vom Rath; on the crystalline form of lanarkite, by A. Schrauf; on the regular grouping of quartz crystals on calcite, by E. S. Dana; on the dimorphism of hydrochinon and paranitro phenol, by O. Lehmann; a manganese variety of tremolite, by G. A. Koenig; on the form of crystals of barium sulphate, etc., by H. Baumhauer; on the schorlomite from the Kaiserstuhl, by A. Knop. In addition to the above articles, a series of notices and extracts, upwards of thirty in number, and covering as many pages, follow. These are derived from a great variety of sources, and form not the least valuable part of the number. Under the able editorship of Professor Groth, it cannot be doubted that the new Journal will always maintain the high character it has at its commencement. E. S. D.

13. *Ueber den inneren Zusammenhang der verschiedenen Krystallgestallten des Kalkspaths,* von Dr. F. Scharff; 61 pp. 4to, with five plates. Frankfort, 1876.—The memoirs previously published by Dr. Scharff upon the interior crystalline structure of several

mineral species, as quartz, feldspar, gypsum, have been most valuable contributions to the subject of Crystallogeny; and the same is eminently true of the present memoir upon Calcite. Dr. Scharff describes with great care and minuteness the results of his observations upon a large series of calcite crystals, and the descriptions are further elucidated by many excellent figures. His attention was especially directed to those cases in which the formation of the crystals was incomplete, or had been in some way interrupted, and from these sources he draws his conclusions as to the method of formation of the crystals, and the conditions determining their growth. E. S. D.

14. *Upon the Chemistry and Composition of the Porcelain and Porcelain-rocks of Japan;* by HENRY WURTZ.—Dr. Wurtz has published, in a recent number of the American Chemist, a paper of some length upon the porcelain-making of the Japanese, prepared by him in his capacity as Judge in one of the departments of the Centennial Exhibition. He gives a description of the occurrence of the materials in Japan, and the methods employed in the preparation of the porcelain from them. The chemical composition of both the natural materials in their different varieties and the manufactured products are also given at length in a series of analyses.

III. BOTANY AND ZOOLOGY.

1. *Dictionnaire de Botanique, par* M. H. BAILLON, Paris. (Hachette & Cie.)—We noticed the first fascicle at the time of its appearance. The second and third are now received, reaching to p. 240, and to the article *Apothecium;* so that about 300 pages will be devoted to the first letter of the alphabet. The work must needs be voluminous, for it is a veritable encyclopedia, and various articles have developed almost into treatises, with profuse and excellent wood-cut illustrations. The main articles of this sort in the present fascicles are *Albumen*, *Aleurone*, *Algæ*, *Aliments des plantes*, *Alternance des générations*, *Amidon* (starch), *Androcée* (which should be, as M. Littré says, *Andrœcie*, under which synonym only is the proper derivation given), *Anthère*, *Antheridie*, and *Antherozoides*. The work improves as it advances, and if in danger of being too bulky, it is certainly low-priced, considering execution, and fullness of illustration.

Under *Ainsliæa*, by some mischance, it is said that to this imperfectly known genus, *Parthenice* Tor. & Gray probably belongs; and over the leaf there is something equally confounding under *Aiolotheca*. The explanation is that the last five lines of the two articles have been accidentally transposed in manuscript or type, and then one word altered in proof-reading. A. G.

2. *Flora Fossilis Arctica; Die Fossile Flora der Polarländer*, von Dr. OSWALD HEER, Vierter Band, mit 65 Tafeln, 4to, Zurich, J. Wurster & Comp. 1877.—This fourth volume of a classical, and to us particularly interesting work, is a collection of three memoirs.

First, Beiträge zur fossilen Flora Spitzbergens; with a geological appendix, by Prof. Nordenskiöld. This belongs to the fourteenth volume of the memoirs of the Royal Swedish Academy of Sciences, Stockholm, no. 5, issued in 1876.

Second, Beiträge zur Jura-Flora Ost-Sibiriens und des Amurlandes, is from the memoirs of the Imperial Academy of Sciences, of St. Petersburg, vol. xxii, issued in 1876.

Third, A small part, with only two plates, Ueber die Planzen-Versteinerungen Von Andö in Norwegen, apparently has not elsewhere appeared.

This East Siberian Jurassic flora is rich in Gingkos (seven species), with some allied Taxineous genera, as well as some *Taxodieæ*, more *Abietineæ*, and three Monocotyledons (*Pandaneæ*). The Spitzbergen deposits referred to that era, furnish six or seven species or forms of Gingko, three Pines, and a sort of Bamboo; the Cretaceous, three or four Pines, Sequoias, a *Torreya*, etc.; and the Miocene has *Taxodium*, *Glyptostrobus*, *Sequoia*, *Cyperus*, *Carex*, *Maianthemum*, *Alisma*, seven Poplars, two Alders, three Hazels, a Hornbeam, a Beech, four Oaks, an Elm, a Plane-tree, an Ivy, five species of *Cornus*, two of *Nyssa*, and a *Nyssidium*, two of *Magnolia*, a *Parrottia*, a *Tilia*, three Maples, a *Kœlreutera*, three Hawthorns, and a veritable fossil strawberry! A. G.

3. *Proceedings and Transactions of the Nova Scotia Institute of Natural Science*, vol. iv, part 2, 1877.—This part is rather rich botanically. Professor Sommers institutes an elaborate comparison between the flora of Nova Scotia and that of Colorado. Rev. E. H. Ball, gives an interesting and readable account of the Ferns of Nova Scotia. Prof. Lawson, in notes upon some Nova Scotian plants, takes up the *Calluna vulgaris* question, enumerates the known stations in the provinces, and the circumstances and condition of most of them; and concludes that while one or two of them may be artificial, "it has been originally a native indigenous plant," and "that the various traditions as to the foreign origin of the heather, are not unlikely to have been suggested by the desire to account for the presence of what was regarded as necessarily a foreign plant, rather than by actual historical facts." There are several communications relating to *Rhododendron maximum*, which has its northern and eastern limit in Nova Scotia. Finally, Professor Sommers gives a catalogue of the plants of the Province.

A. G.

4. *Lady Smith*, the widow of Sir James Edward Smith, and his survivor for almost half a century, died on the third of February last. She was born, May 11, 1773. An authenticated copy of the register of her baptism was printed in the London Times (which has been skeptical about centenarians) along with an interesting biographical notice. There is no room for doubt that, if she had survived three months longer, she would have been 104 years old. She not only lived long but enjoyed life to the last. She wrote a clear and firm hand, at least up to her hundredth year; her eyesight of late failed only so far that she was unable longer to read or guide her pen; "her hearing was at worst only a little hard," her teeth were almost perfect, and her memory was nearly unimpaired. Since Dr. Torrey's death, probably the only surviving

correspondent of her husband is Dr. Jacob Bigelow, who on the 27th of February attained the age of 90. A. G.

5. *Joseph de Notaris*, the distinguished Italian Bryologist, who was born on the 5th of May, 1805, and who was lately transferred from the chair of botany in the University of Genoa, to that at Rome, died on the 22d of January last. A. G.

6. *Recent Papers on Fungi.*—The following are articles of interest, which have recently appeared:

(1.) *Reproduction des Ascomycetes*, par M. MAX CORNU,—Annales des Sciences Naturelles, 6^{e} Série. Tome iii.

(2.) *Beiträge zur Kenntniss der Pycniden* 1; von Dr. HERMANN BAUKE.—In the two papers by Cornu and Bauke, an attempt has been made to discover the nature of the organs known as *spermatia*, *stylospores*, and *pycnidia*. The two last named organs, since the publication of Tulasne's Carpologia, have been generally admitted to be secondary forms of species of Ascomycetes. Certain cases, however, seemed to point to the conclusion that some pycnidia were independent organisms, and it was to settle this point that Dr. Bauke made his investigations. His method consisted in the artificial cultivation of different spores, and resulted in a general confirmation of Tulasne's views. The observations of Cornu have extended over several years; and, in regard to the spermatia, he comes to the conclusion that they cannot be considered male organs. He has observed that they germinate, and thinks that they must be regarded as a form of stylospore. Although contrary to the view generally maintained as to the nature of spermatia, and to the views expressed by Stahl in the Bot. Zeitung, Mar. 20, 1874, Cornu's view coincides with what has recently been published in the Bot. Zeitung and Comptes Rendus with regard to the supposed spermatia of species of Coprinus by Brefeld and Von Tieghem. The reason why the germination of spermatia has not been seen until recently is explained by Cornu by the fact that most cultures of spermatia have been made with pure water, whereas the presence of some special nutritive fluid, as solution of gum, bark, etc., seems to be necessary. Cornu was led to this conclusion by noticing that, when sown on a glass slide, under a cover-glass, the spermatia germinated more readily on the side next the gummed label.

(3.) *Ueber den Gitterrost der Birnbäume und seine Bekämpfung;* von Dr. G. KRAMER; An interesting paper in the Schweizerische landwirthschaftliche Zeitschrift on a disease of pear trees, caused by *Rœstelia cancellata* Rebent, which Dr. Kramer agrees with Oersted in considering a form of *Podesoma fuscum* Duby occurring on *Juniperus sabina*, L. W. G. F.

7. *Destruction of Forest Trees by Mistletoe;* by E. S. CROZIER. (From letter to Editors dated Louisville, Ky., March 9, 1877.)—The American Mistletoe (*Phoradendron flavescens*) is very common in this latitude (38°), and bids fair to become an important factor in the forest culture of regions favorable to its growth. It grows luxuriantly upon the branches of the elm and black walnut; and it has increased to such an extent that large forests of the latter

are now almost destroyed. In many sections this valuable timber has entirely disappeared; and in others the branchless trunks, still standing, attest the destructive effects of this parasite. As soon as a bunch of mistletoe fixes itself upon a branch, the outward extremity ceases to grow, and finally dies. The tree soon presents a clubby appearance, followed by death. A grove of black walnuts, just east of this city, was notable a few years ago for its depth of foliage and the thrifty growth of its individuals. It is now a picture of desolation. A few years will witness its total destruction. The importance of this subject to the industrial interests of the country should commend it to the attention of those interested in arboriculture, in the hope that some means may be devised for preventing the ravages of this parasite.

8. *Median and Paired Fins, a Contribution to the history of Vertebrate Limbs;* by JAMES K. THACHER.—This memoir is from volume iii of the Transactions of the Connecticut Academy. It is the result of a careful comparison of the fins of various species of fishes at early stages of growth, and is illustrated by twelve plates. The view reached is in opposition to that of Gegenbaur on the subject, and is expressed thus:

As the dorsal and anal fins were specializations of the median folds of Amphioxus, so the paired fins were specializations of the two lateral folds which are supplementary to the median in completing the circuit of the body. These lateral folds, then, are the homologues of the Wolffian ridges, in embryos of higher forms. Here, as in the Median fins, there were formed chondroid and finally cartilaginous rods. These became at least twice segmented. The orad ones, with more or less concrescence proximally, were prolonged inwards. The cartilages spreading met in the middle line, and a later extension of the cartilages dorsad completed the limb girdle.

If now we seek to determine the form of limb for the Protognathostomi, that is to say, for that time for which the archipterygium in its entirety is proposed, we should propose this:

The limbs of the Protognathostomi consisted of a series of parallel articulated cartilaginous rays. They may have coalesced somewhat proximally and orad. In the ventral pair they had extended themselves mesiad until they had nearly or quite met and formed the hip girdle. They had not here extended themselves dorsal. In the pectoral limb the same state of things prevailed, but was carried a step further, namely, by the dorsal extension of the cartilage constituting the scapular portion, thus more nearly forming a ring or girdle.

IV. ASTRONOMY.

1. *Elements of Borelly's Comet;* by AARON N. SKINNER, Assistant U. S. Naval Observatory. (From a letter to the editors, dated Washington, D. C., March 13, 1877.)—I have deduced the following elements of Borelly's Comet from equatorial observations made at this Observatory, February 9, 12 and 17.

$$T = 1877,\ \text{Jan. } 18{\cdot}9658,\ \text{Wash. M. T.}$$

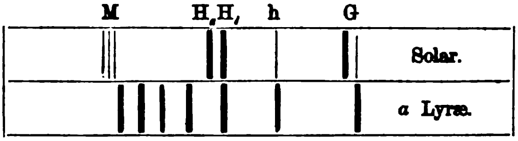
$$\left.\begin{aligned}\pi &= 174^\circ\ \ 15'\ \ 32''\\ \Omega &= 187\ \ \ \ 10\ \ \ \ \ 4\\ i &= 152\ \ \ \ 20\ \ \ \ 28\end{aligned}\right\}\ \text{Apparent Equinox, Feb. } 13{\cdot}7.$$

$$\log g = 9{\cdot}90709$$

The constants for computing the rectangular coördinates are:

$$\begin{aligned} x' &= 9{\cdot}90639 \sin\left(250^\circ{\cdot}7068 + v\right) \sec^2 \tfrac{1}{2}v\\ y' &= 9{\cdot}71223 \sin\left(336^\circ{\cdot}7634 + v\right) \sec^2 \tfrac{1}{2}v\\ z' &= 9{\cdot}79456 \sin\left(343^\circ{\cdot}4010 + v\right) \sec^2 \tfrac{1}{2}v\end{aligned}$$

2. *Note on the Photographic Spectra of Stars;* by WILLIAM HUGGINS, D.C.L., LL.D., F.R.S. (From the Proceedings of the Royal Society, No. 176, 1876).—In the year 1863 Dr. Miller, and myself obtained the photograph of the spectrum of Sirius. "On the 27th January, 1863, and on the 3d of March of the same year, when the spectrum of this star (Sirius) was caused to fall upon a sensitive collodion surface, an intense spectrum of the more refrangible part was obtained. From want of accurate adjustment of the focus, or from the motion of the star not being exactly compensated by the clock movement, or from atmospheric tremor, the spectrum, though tolerably defined at the edges, presented no indications of lines. Our other investigations have hitherto prevented us from continuing these experiments further; but we have not abandoned our intention of pursuing them."* I have recently resumed these experiments by the aid of the 18-inch speculum belonging to the Royal Society's telescope in my possession. Considerable delay has arisen from the necessity, for these observations, of a more uniform motion of the driving-clock. For this purpose, Mr. Howard Grubb has successfully applied to the clock the control of a seconds pendulum in electric connection with a sidereal clock. This system works quite satisfactorily. The prisms employed are made of Iceland spar, and the lenses of quartz. After an extensive trial of different photographic processes, preference has been given to dry plates. The apparatus is so arranged that a solar or electric spectrum can be taken on the same plate, for the purpose of comparison, with the spectrum of the star. Spectra have been obtained of Sirius, Vega, Venus, the Moon, etc. I do not purpose in this preliminary notice to describe in detail the arrangements of the special apparatus which has been constructed, nor to offer the results of the experiments in their present incomplete state to the Royal Society. Still I venture to hope that, even in this early stage of the inquiry, the enlarged copy of the spectrum of Vega (α Lyræ) which accompanies this note may not be regarded as altogether unworthy of



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* Phil. Trans., 1864, p. 428.

attention. After exposure to the light of Vega, the dry plate was allowed to remain in the instrument until the following morning, when a solar spectrum was taken upon it, through the half of the slit which had remained closed when the instrument was directed to the star. The photograph shows seven strong lines, all of them slightly shaded at the sides. The two lines which are least refrangible coincide with two known lines of hydrogen in the solar spectrum. It is expected, by means of an apparatus now in the course of construction, to obtain also any finer lines which may be present in the spectrum of this star, as well as to extend the photographic method to stars which are less bright. I need not now refer to the many important questions in connection with which photographic observations of stars may be of value.

3. *Tables of the Satellites of Jupiter;* by D. P. Todd. 40 pp. 4to.—Published for the American Ephemeris by authority of the Secretary of the Navy. The tables of Damoiseau published in 1836 give the places of Jupiter's satellites up to the year 1880. The present tables are a continuation of Damoiseau's by the same formulæ and elements to the year 1900.

V. Miscellaneous Scientific Intelligence.

1. *Geological Society of London.*—At the Annual Meeting, February 16th, the Wollaston Gold Medal was presented by the President of the Society, to Mr. Robert Mallet, for his able researches on earthquakes, volcanoes, volcanic energy, and other important scientific labors; the Murchison Medal to Rev. W. B. Clarke, of Sydney, Australia, for his various geological discoveries during the half century past in New South Wales; the Lyell Medal and part of the Lyell Fund to James Hector, Director of the Geological Survey of New Zealand; the balance of the proceeds of the Lyell Fund, to Mr. Pengelly, for his explorations of Kent's Cavern.

At the same time the Bigsby Medal, founded last year by Dr. Bigsby, F.R.S., F.G.S., formerly an able worker in the geology and paleontology of British North America, was given to Prof. O. C. Marsh, of Yale College, "in recognition of the great services which Prof. Marsh has rendered to the paleontology of the Vertebrates;" whose studies include "fossil remains of nearly every great group of the Vertebrata from the Paleozoic, Cretaceous and Cenozoic strata of the New World," and "are so numerous and so important as to mark an epoch in this line of research."

2. *Bulletin of the Buffalo Society of Natural Sciences*, vol. III, No. 4. 1877.—This number of the bulletin contains a check-list of the fresh-water fishes of North America (concluded) by D. S. Jordan; the Shinumos, by F. S. Dellenbaugh; on the peopling of America, by A. R. Grote; on the Hyphomecetous Fungi, by M. C. Cooke. Mr. Grote's paper applies the idea respecting the migrations of species in consequence of the

approach and retreat of the cold and ice of the Glacial era (which has been illustrated by different authors with respect to plants and animals generally, and in Europe as regards man) to man in North America, but without any special facts in proof of the suggested migration.

3. *The California State Geological Society* "has been recently incorporated for the purpose of making a collection of mineral products of the Pacific coast," promoting the progress of economic Geology, and "encouraging the study of Geology in all its branches." The President of the Society is Mr. HENRY G. HANKS, and the Secretary S. HEYDENFELDT, Jr.

4. *Meteorology of Golden, Colorado*, in lat. 39° 44′ 24″ N., long. 28° 8′ 10″ W., 5,618 feet above the sea.—Mean temperature for 1876, 51·64° F.; precipitation 18·36 in.; mean temperature of the warmest day 80·7° F.; do. of the coldest day (March 10) 8° F. above zero; mean temperature of the winter months, 36·18° F.; spring, 45·90; summer, 69·90; autumn, 54·60; winds between N.E. and S.E. 20 to 30 days for the several seasons, and between W., S. and S.E. 20 to 30 days for the several seasons, and between N. and S.W., 57 to 72 days for the seasons.—*E. L. Berthoud, in Colorado Transcript* for Jan. 10.

5. *The American Microscopical Society of the City of New York.*—At the annual meeting held January 9th, the following officers were elected for the ensuing year: President, John B. Rich, M.D., 1 West 38th street, N. Y.; Vice-President, Wm. H. Atkinson, M.D., 41 East 9th street, N. Y.; Secretary, O. G. Mason, Bellevue Hospital.

6. *Remarks on the Structure of Precious Opal.*—Prof. LEIDY has an article in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1876, p. 195, on the microscopic structure of the opal of Queretaro, Mexico.

7. *Shoal in the Atlantic* 300 *to* 400 *miles northeast of Madeira and* 130 *miles from Cape St. Vincent.*—Commander Gorringe, of the United States sloop Gettysburg, has discovered a bank in 36° 29′ N. and 11° 33′ W. with only thirty-two fathoms water over it, and 1525 fathoms to the southeast and southwest of it. It is about 200 miles west of the Josephine Bank which has a depth of eighty-two fathoms, and lies nearly in a line between Madeira and Cape St. Vincent. *Nature*, of March 1, gives a map of that portion of the Atlantic from Capt. Gorringe's soundings and those of the Challenger, in January, 1873, and the German frigate Gazelle, in 1874.

OBITUARY.

WOLFGANG SARTORIUS VON WALTERSHAUSEN, the distinguished author of works and memoirs on volcanic rocks, minerals, and phenomena, including extended treatises on those of Iceland and Etna, and Professor of Mineralogy and Geology in the University of Göttingen, died on the 16th of October last, at the age of nearly sixty-seven. He was the author also of memoirs on terrestrial magnetism, meteorology and paleontology.

THE

AMERICAN

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[THIRD SERIES.]

ART. XXXVII.—*On Vortex Rings in Liquids*; by JOHN TROWBRIDGE, S.D., Assistant Professor of Physics. (*Contributions from Physical Laboratory of Harvard College.* No. XVIII.)

[Presented at the Meeting of the Am. Acad. of Arts and Sciences, Mar. 14, 1877.]

IT has often been observed by chemists that a drop of colored liquid falling from a burette into a liquid of a different specific gravity, in which it can diffuse, assumes the form of a ring. Vortex motion, by the researches of Helmholtz, Thomson, Rankine, and Maxwell, is now attracting so much attention, that I have thought that a study of the general equations of motion of matter in connection with a study of these rings would contribute to our knowledge of vortex movement.

Prof. W. B. Rogers published in this Journal, xxvi, 1858, a paper on smoke rings and liquid rings, and described several methods of studying them. In Professor Tait's "Recent Advances in Physical Science," a method of forming smoke rings is given. The apparatus consists merely of a large box closed at one end by a thin sheet of india rubber, or with a tightly stretched towel, and having a circular opening of six or eight inches in diameter at the other. Clouds of sal-ammoniac vapor are generated inside the box, and rings are expelled from the circular opening by a blow upon the rubber or towel. Sir William Thomson suggests that two such boxes placed so that the rings may impinge on each other at any angle would form a useful apparatus for studying the behavior of such rings toward each other. At the conclusion of this paper, several methods of studying liquid rings will be described. When a drop of liquid falls from a short distance into a liquid of less density, in which it cannot diffuse, the conditions of its motion just after the instant of its striking the surface of the liquid of less density are indicated by the general equations of heterogeneous strains.* "For each particle we have the component velocities u, v, w, parallel to the fixed axes OX, OY, OZ. These have the following expressions:

$$\text{Eq. (1)}: \; u=\frac{d\alpha}{dt}, \qquad v=\frac{d\beta}{dt}, \qquad w=\frac{d\gamma}{dt};$$

x, y, z, t being independent variables, and α, β, γ, functions of them. If the disturbed condition is so related to the initial condition that every portion of the body can pass from its initial to its disturbed position and strain, by a translation and a strain without rotation,—i. e., if the three principal axes of the strain at any point are lines of the substance which retain their parallelism,—we must have—

$$\text{Eq. (2)}: \; \frac{d\beta}{dz}=\frac{d\gamma}{dy}, \qquad \frac{d\gamma}{dx}=\frac{d\alpha}{dz}, \qquad \frac{d\alpha}{dy}=\frac{d\beta}{dx};$$

and, if these equations are fulfilled, the strain is now rotational, as specified." But these equations express that $\alpha dx+\beta dy+\gamma dz$, is the differential of a function of three independent variables; and therefore, in order that there may be no rotation, a strain potential must exist. The forces which solicit the particles of the drop when it rests upon the liquid of less density in which it cannot diffuse are evidently their mutual attraction, a force arising from the superficial tension of the liquid, and one arising from gravitation. It is evident, from a consideration of these forces, that, after the drop has suffered a strain at the surface, every portion of the drop cannot pass from its initial position to the next following by a translation and a strain without rotation. For the drop tends to return from a shape approaching an oblate spheroid to that of a sphere. Equations (2) do not hold, and a strain potential does not exist, and therefore this drop must rotate. This rotation is not in general of the ring form. If, on the other hand, the drop of liquid can diffuse itself in the liquid through which it falls, each particle with the velocity u, v, w, is solicited at the moment of impact by a superficial tension, by the force of gravitation, and by a force arising from the rate of diffusion. In this case, there is no tendency of the body to reassume the spheroidal or spheroid form in its passage through the liquid. On the other hand, to assume that each particle in the next state of the drop very near that which it assumes on striking the free surface of the liquid of less density, is translated without rotation, is to assume that each particle is compelled to move in restrained limits which do not exist. For the components X^1, Y^1, Z^1, of the attraction, which tend to make the non-diffusible drop reassume its spherical form, we have in the case of the diffusible the components X, Y, Z, of an external force arising from the superficial tension of the liquid, and the impulse given to the drop.

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* Thomson and Tait's Natural Philosophy.

If we follow the notation of Poisson* and Helmholtz,† we shall have for the general equations of internal motion of a liquid:

$$\left.\begin{aligned} X-\frac{1}{h}\frac{dp}{dx}&=\frac{du}{dt}+u\frac{du}{dx}+v\frac{du}{dy}+w\frac{du}{dz}\\ Y-\frac{1}{h}\frac{dp}{dy}&=\frac{dv}{dt}+u\frac{dv}{dx}+v\frac{du}{dy}+w\frac{du}{dz}\\ Z-\frac{1}{h}\frac{dp}{dz}&=\frac{dw}{dt}+u\frac{dw}{dx}+v\frac{dw}{dy}+w\frac{dw}{dz}\end{aligned}\right\}\quad(3)$$

$$\frac{dh}{dt}+u\frac{dh}{dx}+v\frac{dh}{dy}+w\frac{dh}{dz}=\frac{\delta h}{\delta t}\quad(4)$$

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=0\quad(5)$$

In which p is the pressure in a liquid at the point x, y, z; X, Y, Z, are the components of the external forces acting on a unit of mass; and h is the density. When the variation of h is infinitely small, we have Eq. (5). The forces X, Y, Z, are considered to have a potential V. So that

$$X=\frac{dV}{dx},\qquad Y=\frac{dV}{dy},\qquad Z=\frac{dV}{dz}\cdot\quad \text{Eq. (6)}$$

and the velocities u, v, w, a velocity potential Φ. So that

$$u=\frac{d\varphi}{dx}\qquad v=\frac{d\varphi}{dy}\qquad w=\frac{d\varphi}{dz}\qquad \text{Eq. (7)}$$

or

$$udx+vdy+wdz=d\varphi,$$

and φ satisfying the equation

$$\frac{d^2\varphi}{dx^2}+\frac{d^2\varphi}{dy^2}+\frac{d^2\varphi}{dz^2}=0$$

which is what equation (5) becomes under the conditions expressed above. We must therefore have

$$\frac{du}{dy}=\frac{dv}{dx},\qquad \frac{dv}{dz}=\frac{dw}{dy},\qquad \frac{dw}{dx}=\frac{du}{dz}\quad \text{Eq. (8)}$$

equations similar to the equations expressing a strain potential. Helmholtz has shown that in the case of rotation of a fluid element, Eqs. (8) become

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* Traité de Mechanique. † Crelle's Journ., lv, 1858.

$$\left.\begin{array}{l} \dfrac{dv}{dz}-\dfrac{dw}{dy}=2\xi \\[2ex] \dfrac{dw}{dx}-\dfrac{du}{dz}=2\gamma \\[2ex] \dfrac{du}{dy}-\dfrac{dv}{dx}=2\zeta \end{array}\right\} \qquad \text{Eq. 9.}$$

and therefore "the existence of a velocity potential is inconsistent with the existence of rotation of the fluid element." We have seen from the equation of strain that the existence of a strain potential is inconsistent with the rotation of a material particle. Let us now see if vortex movement can arise in a liquid from variation of density and pressure. Following Helmholtz's notation, we have, if ψ is a function of x, y, z, t,

$$\frac{\delta\psi}{\delta t}=\frac{d\psi}{dt}+u\frac{d\psi}{dx}+v\frac{d\psi}{dy}+w\frac{d\psi}{dz} \qquad \text{Eq. (10).}$$

Calling ξ, γ, ζ, the components of the angular velocity, we can obtain their variations by substituting them in succession in Eq. (10). If we eliminate X, Y, Z, from Eqs. (3) by the help of Eqs. (6), supposing that h and p are functions of x, y, z, t, we obtain, introducing the values of ξ, γ, ζ, from Eqs. (9):

$$\text{Eq. (11).}\ \frac{\delta\xi}{\delta t}=-\xi\left(\frac{dv}{dy}+\frac{dw}{dz}\right)+\gamma\frac{dv}{dx}+\zeta\frac{dw}{dx}+\frac{1}{2h^2}\left(\frac{dh}{dz}\cdot\frac{dp}{dy}-\frac{dh}{dy}\frac{dp}{dz}\right)$$

and similar expressions for the variations of γ and ζ. If the variation of h is infinitely small, we obtain by the aid of Eq. (5):

$$\frac{\delta\xi}{\delta t}=\xi\frac{du}{dx}+\gamma\frac{dv}{dx}+\zeta\frac{dw}{dx}$$

If it is not infinitely small, we have the term

$$\frac{1}{2h^2}\left(\frac{dh}{dz}\frac{dp}{dy}-\frac{dh}{dy}\frac{dp}{dz}\right)$$

which is independent of ξ, γ, ζ, and depends upon the variation of h and p. This term enters into the expressions for the variations in the angular velocities; and shows, therefore, that a vortex movement can arise in a process of diffusion by a variation in density and pressure, without the aid of initial angular velocities. This condition can be shown experimentally by dropping a somewhat dense solution of one of the aniline colors into a mixture of glycerine and water. The original ring, after ceasing to move downward in the mixture, breaks up gradually into segments, which slowly in their turn assume the ring form. A mixture of water and glycerine is not necessary: peculiar cusp-like figures indicating the first stage of vortical movement can be seen whenever a thin stratum of one liquid slowly diffuses itself through another liquid of different density.

By a consideration of the equations—

$$\varepsilon\xi + (u_1 - u)dt = \varepsilon\left(\xi + \frac{\delta\xi}{\delta t}dt\right)$$

$$\varepsilon\gamma + (v_1 - v)dt = \varepsilon\left(\gamma + \frac{\delta\gamma}{\delta t}dt\right)$$

$$\varepsilon\zeta + (w_1 - w)dt = \varepsilon\left(\zeta + \frac{\delta\zeta}{\delta t}dt\right)$$

given by Helmholtz, from which he draws the conclusion that "each vortex line remains continually composed of the same elements of fluid, and swims forward with them in the fluid," we see, on introducing the new expressions which we have found for $\frac{\delta\xi}{\delta t}$, &c., Eq. (11), that we approach nearer and nearer to this theoretical conclusion when the variations of h are smaller and smaller. Obviously, we should then obtain the most perfect rings when the drop and the liquid in which the motion takes place are composed of the same liquid. And, *therefore, a drop of water falling into water must form a more perfect ring than that formed by a drop of any colored liquid of greater density than water.*

The formation of these liquid rings is as fascinating and as simple an occupation as blowing soap-bubbles. All liquids falling from such a height that the surface of the liquid is not too much disturbed to enable the drop to be acted upon symmetrically by the forces at the free surface will form rings, if too great differences of density do not exist, and if the drop can diffuse in the liquid. The preceding mathematical discussion, as we have seen, shows us that a drop of pure water on striking the same element under the above conditions must necessarily assume the ring shape. This can be shown experimentally by covering the free surface of the water with a fine powder, or with matter in a fine state of subdivision. I have found that an alcoholic tincture of ginger, which gives on the surface of water a milky liquid consisting of particles in a fine state of subdivision, answers the purpose very well. Fine particles will be carried down by the drop, and will be seen to rotate in a vortex ring far below the surface. This fact can be stated, also, by the employment of any of the aniline colors which are solvent in water, the falling drop consisting of a colored solution, whose specific gravity does not differ sensibly from that of water. The method that I have employed to produce the rings consists merely of a small glass tube, slightly smaller at one end than the other. A bit of cotton is wedged in nearer the larger end, over which a piece of flexible rubber tubing is slipped. With the aid of the mouth, one can fill this tube with liquid and eject it in drops at pleasure. The same apparatus enables us to form the rings beneath the surface of the liquid. With a tube bent horizontally, one can send the rings through a liquid in any desired direction; and, by means of a three-way glass joint and a small india-rubber bag, one can send forth, by the same impulse, two rings whose paths make any desired angle with each other. By partly immersing the glass tubes connected with the three-way tube in the free surface of the liquid, and covering the surface of the water with fine powder, one can study the mutual behavior of half vortex rings. A simpler method is to illuminate, by means of a gas-light, the bottom of a flat, white porcelain dish filled with water, and to observe the shadows of the half-vortex rings on the bottom of the dish formed by the movement of two spatulae along the surface. It can be readily seen, by this simple method, that a half-vortex ring moving near another in a parallel path and with a less velocity tends to follow in the path of the first; and that two equal half-vortex rings moving in opposite directions along the same path separate into two vortices which move at right angles to the path of the original vortices. We can conclude, also, from this general discussion, that, whenever a mass of vapor of greater density than the surrounding air is suddenly formed in the higher regions of the atmosphere, it tends to descend through it in a vortex ring.

The results of the preceding discussion are as follows:

1. An analogy between the strain potential and the velocity potential is indicated.
2. It is shown that the formation of liquid rings is a necessary result of the fundamental equations of strains and those of hydrodynamics; and that they constitute a general and not a special phenomenon. A drop of water falling into water from a suitable height must assume a ring shape.
3. Vortices can and do arise in certain processes of diffusion.
4. Simple methods of studying vortex motion in liquids are given.

ART. XXXVIII.—*An account of the Discoveries in Vermont Geology of the* Rev. AUGUSTUS WING; by JAMES D. DANA.

THE death of the Rev. Augustus Wing, in January, 1876, deprived the country of an excellent geological observer, and science of the results, to a large extent, of his long labors.* During the preceding summer, in July, I had the pleasure of an excursion with him to various localities over the country between

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* See this Journal, III, xi, 334.

Rutland and Monkton, Vermont, and derived much profit from the survey of the region he had explored, and from the information he communicated in conversation. When we parted he promised to prepare a paper containing the results of his observations for publication. His decease having prevented the accomplishment of his purpose, I have felt it a duty to him and to science to consent to perform, with the aid of such material as I could obtain, the unfulfilled task; and the following article is the result.

My sources of information have been two small note-books and a few of his letters, received from his family through Prof. Henry M. Seely, of Middlebury College. But these letters are, in part, long accounts of his geological observations and views, written at different times during the ten years over which his explorations extended,—probably in response to enquiries from those to whom they were addressed. Among them, one, of many pages, bearing the date, August 9, 1872, is addressed to me, and was written, as it states, on receiving a request from me, dated August 3, for "a fuller account of the fossils of West Rutland," a brief note on his discoveries by Mr. E. Billings, being all hitherto published. No copy of this letter ever left his hands, nor even an acknowledgment of the request; and it is probable that the same is true of the others. His disinclination to write, and his reluctance to make his results public, so long as doubts remained, were, in all probability, the occasion of these many unfinished epistles. But if hesitating with his pen, he was all energy and enthusiasm in exploration. It was in 1865 that he came to the determination "to ascertain, if possible, the geological age of the limestones, slates and quartzytes of Otter Creek Valley;" and ever afterward he kept at it, "tramping," as he says, "during all the time that could be spared from vigorous teaching." He had his reward while going on with his work; for, as his writings show, he experienced the delight of a child over his discoveries; and, at the same time, he felt the confidence of a thorough worker, that the geological truths developed would sooner or later find their place in the science. He continued his field-work to the last; and it was the fatigue of an excursion in the autumn of 1875, when he was already sixty-seven years old, that brought on his fatal illness.

It is to be regretted that his results were not earlier made public; for they would have given some errors in New England geology a speedier extinction, and helped much to push forward discovery. Mr. Wing, by the use of his spare time amid the duties of teaching, accomplished vastly more for the elucidation of the age of Vermont rocks than had been done by the Vermont Geological Survey. The Vermont Report presents diverse opinions about the Eolian limestone and the formations adjoining, but settles nothing; while Mr. Wing's discoveries shed light not on these rocks alone, but also on the general geology of New England and Eastern North America.

In preparing the following account of his results I have used mainly his letter to me of August, 1872, it being the latest detailed statement of his researches left by him, and it giving his facts and views quite fully in the course of its sixty-two pages. But his earlier and later notes also have furnished some facts. All remarks of my own, or additional facts from others, which are introduced beyond, are put in smaller type.

1. *The Region.*

The region studied by Mr. Wing is part of the area of the crystalline limestone formation of Middle and Southern Vermont —the "Eolian limestone," as named by Hitchcock, in the Vermont Geological Report.* This limestone covers a wide central north-and-south strip of country, extending from the southern boundary of the State to Northern Monkton—a distance of about one hundred miles. The limestone region is bordered on the east almost continuously by ridges of quartzyte, or quartzyte and slates, which extend along the western foot of the Green Mountains. Besides, there are north-and-south dividing ridges or belts of hydro-mica slate† and clay-slate, with sometimes interstratified quartzyte. On the west there are, in some parts, other belts of the slate, and to the north, near the great fault, areas of the Red Sand-rock. These various rocks are so associated that the study of all is involved in that of the Eolian limestone. Moreover they together extend southward into and through Massachusetts.

Mr. Wing's special field of exploration was the part of the limestone region and of the adjoining country lying between Rutland and Monkton. The Eolian limestone formation occupies the broad valley of "Otter Creek" (correctly Otter River), and also those of its main tributaries.

The accompanying map is from the colored chart of the Vermont Geological Report. Mr. Wing's notes suggest several changes; but only two of them have been made, because the information is not sufficiently precise to warrant going further: these are, the elongation of the "central belt of slate" to middle Weybridge, and the closing of the West Rutland limestone area on the north by a junction of the area of slate on the east with the

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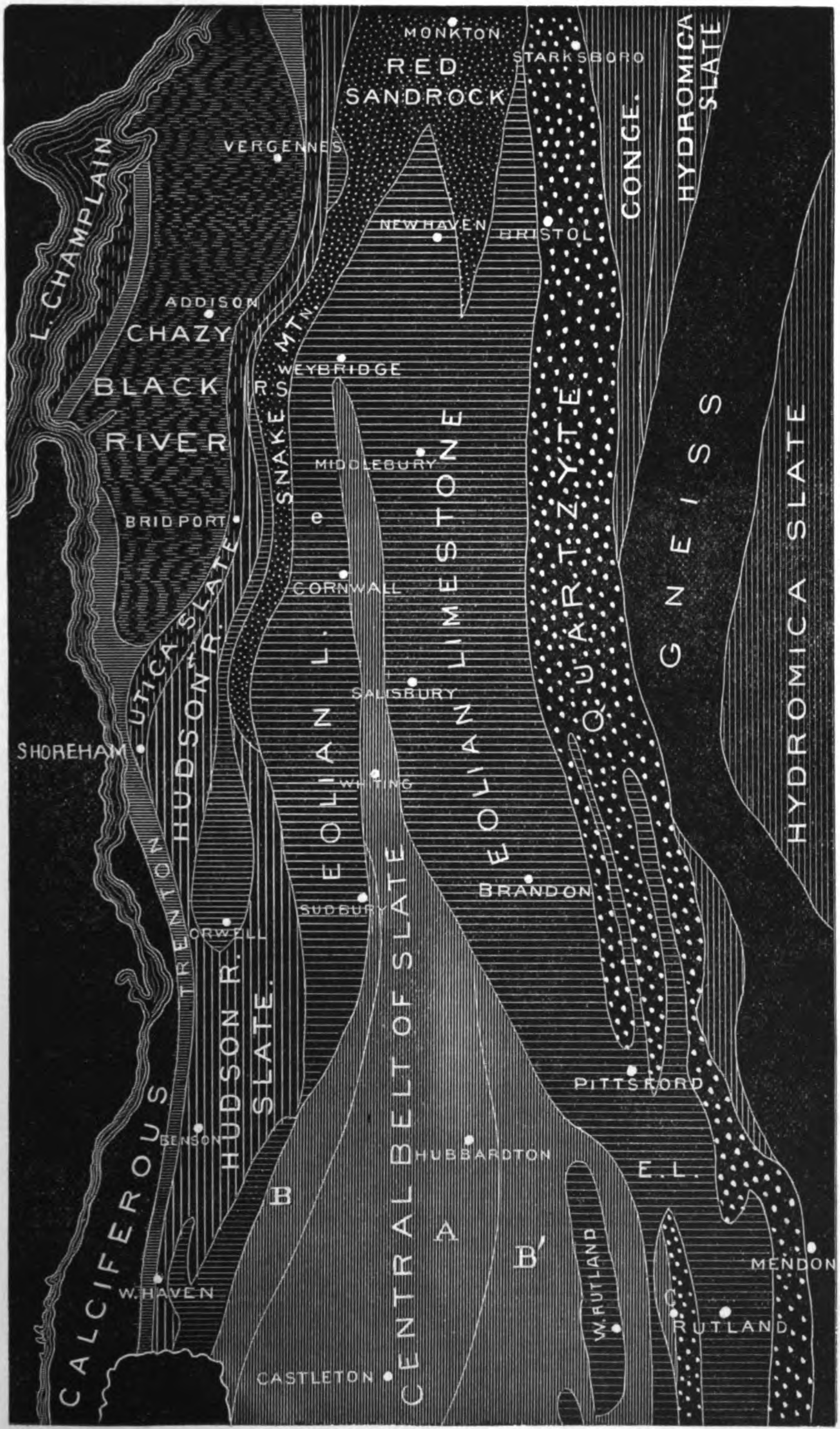
* Report on the Geology of Vermont, by Edward Hitchcock, LL.D., Edward Hitchcock, Jr., M.D., Albert D. Hager, A.M., and Charles H. Hitchcock, A.M. Two vols. 4to, 1861. Published by the authority of the State Legislature.

† The hydro-mica slates include the "Talcoid schist" and "Talcose schist" of the Vermont Geological Report, the fact that they are not talc-bearing or magnesian being one of the results of the survey. Mr. Wing uses the term "Talcoid schists" in his earlier notes, but adopts hydro-mica slates in the later; and I therefore make the substitution whenever the rock is referred to.


MONKTON
RED SANDROCK
STARKSBORO
CONGE.
HYDROMICA SLATE
L. CHAMPLAIN
VERGENNES
NEW HAVEN
BRISTOL
ADDISON
CHAZY
BLACK
RIVER
RS
SNAKE MTN.
WEYBRIDGE
MIDDLEBURY
e
LIMESTONE
QUARTZYTE
GNEISS
HYDROMICA SLATE
BRIDPORT
CORNWALL
UTICA SLATE
HUDSON R.
EOLIAN L.
SALISBURY
EOLIAN LIMESTONE
SHOREHAM
WHITING
TRENTON
SUDBURY
BRANDON
ORWELL
HUDSON R. SLATE.
CENTRAL BELT OF SLATE
PITTSFORD
CALCIFEROUS
BENSON
HUBBARDTON
E.L.
B
A
B′
W. RUTLAND
MENDON
W. HAVEN
C
RUTLAND
CASTLETON

"great central slate belt," that limestone, according to Mr. Wing, not extending to the pond in Pittsford. Besides these, the long Tertiary area, following the eastern border of the main mass of Eolian limestone has been omitted, since it was based on a few local limonite deposits, which were mainly a result of the alteration of either the limestone, or of the slates adjoining associated with the quartzyte, or perhaps partly of the quartzyte itself where impure, and which were forming during earlier as well as later time.

On the map all the areas that are horizontally lined are limestone areas; those vertically lined are slates (hydromica or argillaceous); the dotted area on the east is quartzyte, and the finely dotted on the west and north, Red Sand-rock. The areas most openly lined horizontally are those of the "Eolian limestone," the crystalline or metamorphic limestone, which includes nearly all the marbles of Vermont south of Monkton.

The main or eastern band of the Eolian limestone follows the course of Otter Creek valley, and, no doubt, determined the position of the valley. There is also, north of West Haven, a western band, more or less complete, lying to the west of the "central belt of slate." This great slate-belt extends from Weybridge on the north to the southwestern corner of the State, widening southward and spreading into the State of New York. The part south of Brandon has been called the Taconic range of mountains, it being properly a continuation of the Taconic range of Massachusetts. This belt of slate, over its interior, consists mostly of clay-slate or argillyte (good roofing-slate in many places) (A); but, along either border (B) there is a broad band of hydromica slate, south of Whiting village, this belt is interrupted for a fourth of a mile or so, according to Mr. Wing, and here the limestone to the west of it connects with that to the east in Otter Creek valley. The geological formations on the western border of Vermont, including the Hudson River and Utica shales, with some limestone in the former, the Trenton, Black River, Birdseye and Chazy limestones, are mostly unaltered fossiliferous rocks, and hence their age was long since ascertained. The limestone areas within that of the Hudson River slate are set down as Hudson River limestone in the Vermont map; but Mr. Wing's notes imply that he thought them in part at least Trenton, yet without any special discussion of the subject.

To the east of the eastern quartzyte range there is, east of Bristol, what the Vermont map calls "talcose conglomerate," and next east of this, an area of "talcose schist," the former certainly belonging with the quartzyte, and the latter a hydromica slate, according to evidence in the Vermont Report. Farther east, ranging from the southern boundary of the State, and much of the way adjoining the quartzyte on the east side, there is on the map a broad area of gneiss, often called Green Mountain gneiss. But it is not all gneiss; for the Vermont Report states that Mount Mansfield, the highest mountain of the Green Mountain range, consists partly of chloritic hydromica slate, and this I have found to be true. The true Red Sand-rock, existing more especially in the northern half of Vermont, toward Lake Champlain, has been shown through its fossils, since the Vermont Report was published, to be Primordial. And, by recent discoveries also, it has been proved that the Primordial of Northern Vermont includes an extensive formation of clay-slate—the Georgia slates—and a red or reddish mottled limestone, extending from Canada southward to Burlington, and in some parts fossiliferous, called the Winooski limestone. These facts need to be kept in mind when studying the metamorphic rocks of Central and Southern Vermont and Mr. Wing's views about them.

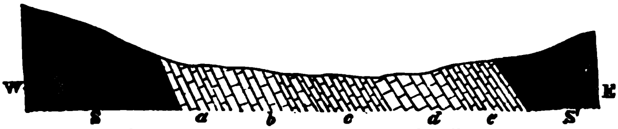
2. *West Rutland Valley.*

The West Rutland limestone valley, famous for its marble quarries, is situated four and a half miles to the west of the city of Rutland. It is separated from the wider limestone band of central Vermont, in which the city of Rutland is situated, by three north-and-south ranges of rock; the first, going west, occurring at Rutland Center (C on map), consists, at the Falls, of quartzyte and an underlying black glossy argillyte, dipping to the southeastward 10° to 20°; the second, is a narrow north-and-south strip of crystalline limestone; the third a narrow north-and-south ridge of black slate, closely resembling that at Rutland Center, and like it in the general direction of its dip, though varying much in the amount of dip and in the strike. This last ridge of black slate makes the eastern boundary of the West Rutland limestone valley, while the slopes of the "great central belt of slate" constitute the western boundary. The rock of these latter slopes is a greenish hydro-mica slate somewhat chloritic.

The limestone of West Rutland valley has a width across of about a mile. It has throughout a high eastward dip—varying between 40° and 70°; and the slates on the west, as well as those on the east, have a corresponding eastward dip. According to Mr. Wing, this band of limestone does not connect on the north with the great central limestone area of Vermont, as the map of the Vermont Geological Report and also Plate VIII represent, but runs out in that direction before reaching the pond in southern Pittsford, through the union of the slate area of the east with the area on the west.

As first discovered by Mr. Wing, this band of limestone contains fossils on both its eastern and western borders, and also along its center. The marble quarries are situated on bands of highly crystalline white and clouded limestone between the fossiliferous borders and the center. The position is shown in the following section: S and S′ are the slates of the two sides, the west and east; *a*, *c*, *e*, the belts of grayish fossiliferous limestone, *b*, *d*, those of the marble quarries. The width of the border belts, *a* and *e*, is from 200 to 300 feet.

1.



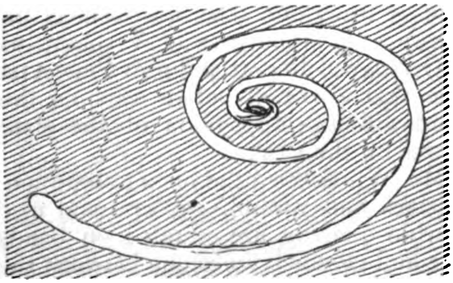
Section across the West Rutland valley.

The fossils of the western border are found in the southwestern part of the valley, just north of an old abandoned marble quarry, the most northern one on the west side of the valley, where the rock is grayer than that of the center belt. The rock here is distinctly and abundantly fossiliferous. It was from this place, at a point rather nearer the quarries than the slate, that the specimens were obtained by Mr. Wing which he sent to Mr. Billings, for his examination. Among them, "a small convoluted shell was in crowded abundance," which Mr. Billings said were like *Pleurotomaria staminea.* A short distance north, crinoidal disks and stems were common; and among these, Mr. Billings distinguished a plate of *Pleurocystites tenuiradiatus*, a Chazy species. Mr. Billings adds to his note on the fossils,* "I think this collection is Chazy. The Cystidean, *Pleurocystites tenuiradiatus*, is a never-failing guide to the Chazy; at least it is so on the west side of Lake Champlain."

On the eastern border of the valley, just east of the large marble quarries, Mr. Wing states that he "found two large convoluted shells, with a *Murchisonia* of moderate size." The limestone of this belt is gray like that of the western. The fossils are, however, much rarer.

At my visit to West Rutland with Mr. Wing, we went first to the central belt, to a place south of the railroad. The rock was found to be, as he had described it, literally full of fossils. The worn surface is crowded with white spots, often having the spiral and other forms of half obliterated shells, besides disks of *Crinoids.* Some of the shells are large distorted *Maclureas*—the well-known Chazy species, and one of these, having the appearance of a white spiral line, is here figured natural size. Other similar specimens are four inches in diameter. The

2.



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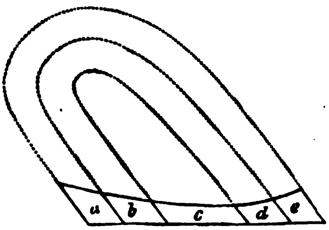
* Published in this Journal, in vol. iv, p. 133, 1872.

gray limestone of the western border of the valley was also found to be abundantly fossiliferous. That of the eastern border, just east of the marble quarries we examined, but in the short time there, no distinct fossil forms were found.

Mr. Wing in his notes explains the position of the Chazy belts in the limestone, and that of the slates either side by the view that the slates lie in synclinals and the limestone in an abraded anticlinal, as illustrated in the annexed figure, making the slates younger than the Chazy. He observes that he had suspected the existence of the Trenton outside of the Chazy between the fossiliferous beds and the slates, but that he had found no evidence of it, and, moreover, the "space was too thin for the normal Trenton."

3.



If there is here but *one* anticlinal, there are two fossiliferous levels in the limestone of the valley, and all the limestone is Chazy; but if a double anticlinal exists, as is possible, though perhaps not probable, then the marble belts may belong to a stratum below the Chazy.

About three miles southwest of West Rutland, in the town of Ira, and within the "great central belt of slates" there are, according to the Vermont Geological Report (p. 432), two outcrops of limestone which afford fossils, and deserve to be called fossiliferous; the fossils found were *Encrinal disks*, and shells resembling a *Euomphalus* in form. Whether related to those of the West Rutland Valley or not cannot be made out from the facts stated.

3. *Sudbury Limestone.*

The Sudbury limestone belt is situated a little over twenty miles north-northeast of West Rutland, on the west side of the "great central belt of slate." The limestone lies between the great band of slate and another on the west, and has a width of two to three miles. The area is bounded both to the north and south by slate, the western slate belt, which leaves the great belt in Benson, joining it again twelve or fifteen miles north, the rock for two miles south of the village of Whiting being slate. Thus the area is isolated like that of West Rutland, and both may be said to be contained within the slate belt. Still, there is a break or interruption in the eastern slate belt toward Whiting, and through it the Sudbury limestone connects directly, or is continuous, with that of Otter Creek valley.

In the Sudbury valley, 1½ miles south of the village, on the land of Mr. Clark Morton, the Trenton trilobite, *Trinucleus concentricus*, was first found in May, 1866, in the blocks of a stone wall which the owner said had been quarried near by; and, Mr. Wing says: "I walked home that night—seven miles—after sundown, glorying in my discovery of a Trenton fossil in Sir William Logan's Quebec Group. I was, however, dampened in all this on reading, after reaching home, in Professor Hitchcock's Report, that the *Trinucleus* had been previously found in a bowlder in Sudbury; for I could not tell whether mine came from a bowlder or not."* But "afterward, in May, 1867, I discovered the Trenton trilobite near the same spot, and in great abundance." It was associated with various other Trenton fossils, twenty or more species of which were later collected by Mr. Billings.

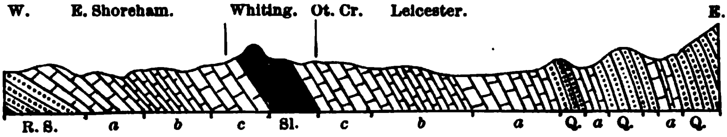
The limestone, like that of West Rutland, and the slates adjoining, all dip eastward. The limestone accordingly, says Mr. Wing, constitutes an anticlinal between two synclinals of slate—those of the slate belts or ridges.

Mr. Wing also states that he afterward found the *Trinucleus concentricus* ten miles southeast of Sudbury (half way to West Rutland) in Hubbardton, in a limestone band sixty yards wide in the heart of the "great central belt of slates;" and also farther south, one or two miles north of the slate-quarries of West Castleton.

4. *Eastern Orwell and Shoreham, Whiting and Cornwall.*

The towns directly north of Sudbury are Whiting and Cornwall, and those adjoining these on the west, Orwell and Shoreham. The area of Eolian limestone—that of its west branch—covers only the eastern half of Orwell and Shoreham, the "great slate belt" occupying the western half. But this slate belt passes northward through the middle of Whiting and Cornwall, so that the western part of each of these towns is

Fig. 4.



Section from the Red sand-rock in Eastern Shoreham to the Quartzyte rocks and interstratified Dolomite of Eastern Leicester, east of the main belt of Eolian limestone.

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* The Vermont Report says (p. 301) only this: "A bowlder of this rock [Trenton limestone] has been found in Sudbury, containing this species, which must have been transported several miles,"—a statement which implies no suspicion of its being a Sudbury fossil.

covered with the western branch of the Eolian limestone, and the eastern with the eastern or Otter Creek branch.

The preceding section is given by Mr. Wing to show the succession of formations across the whole limestone region, from the Red Sand-rock in Eastern Shoreham, to the quartzyte region of Eastern Leicester, a distance of twelve or fourteen miles. It shows the eastward dip throughout; the narrow strip of slate to the west of the middle; and three sections of the Eolian limestone east and west of this slate: *a*, Lower Calciferous; *b*, Upper Calciferous and Quebec; *c*, Chazy and Trenton; R. S., Red Sand-rock; Sl., slates; Q, quartzyte. How far this conclusion is based on positive facts will be seen beyond.

On the *east* side of the slate in East Cornwall various fossils were found in the limestone. These were sent to Mr. Billings, who replied as follows: "The specimens from East Cornwall east of Dr. Porter's residence, and from a locality farther north, are *Stenopora fibrosa*, *St. Petropolitana*, *Escharopora recta?*, part of the rim of a *Trinucleus* or *Harpes*, and species of *Orthis*, *Strophomena*, *Rhynchonella* and *Orthoceras;*" and he added that "they are no doubt Trenton."

North and south of East Cornwall, there are "*Rhynchonella* beds" full of fossils, including pygidia of *trilobites*, a large *Maclurea*, species of *Orthis*, *Encrinal disks*, and other kinds; and, half a mile south, one undoubted *Bathyurus Saffordi*, a Quebec Group trilobite, was obtained.

Near the west border of Cornwall, at *Bascom's ledge* (three miles west of south of West Cornwall and three and one-half miles east of Shoreham), a bed in the "Eolian limestone" is called by Mr. Wing the "Trilobite bed," it being almost made up of remains of trilobites, with other fossils. It afforded—as identified in 1867 by Mr. Billings from specimens sent him by Mr. Wing—*Asaphus canalis*, besides two other species of the genus, two or three species of *Bathyurus*, one of them *B. conicus*, some of the cephalic spines of this species, three, four, and, four and one-half inches long, besides *Maclurea matutina* and other convoluted shells. Mr. Billings made the species Calciferous.

East of Shoreham village the upper limestones hold *Bathyurus extans* Billings (*Asaphus? extans* Hall), a Birdseye species, *Columnaria alveolata*, of the Black River limestone, and the Trenton trilobite, *Trinucleus concentricus*.

Barbour's Ledge, in southern Bridport, near Mr. J. Barbour's residence, affords similar fossils to Bascom's Ledge, including many pygidia of trilobites of the species *Asaphus canalis*, and *Bathyuri*, and also, in an overlying bed, *Maclurea matutina* and other convoluted shells and trilobites.

The "Rhynchonella beds" extend from West Cornwall to a mile or two south of Orwell, fifteen to eighteen miles. But in

Orwell, in higher limestones immediately west of and underlying the "sparry limestone," there occur *Petraia profunda* (?), *Stenopora fibrosa* and *St. Petropolitana*, "which may be Birdseye species;" and at the bottom of a hill one and one-half miles northeast of Orwell village, where the "sparry limestone is largely developed," a number of large *Maclureæ* were found (one, as figured in the notes, three inches in its longer diameter, and resembling fig. 2 on page 338), which seems to indicate the presence of the Chazy limestone beneath the "sparry limestone," or at its base. Higher up toward the top, there are obscure fossils; but at the top, near the slate, occur distinct bivalves, and the coral *Receptaculites Neptuni*, which seems to prove the "Sparry limestone" to be Trenton in age.

In northeastern Shoreham, two miles north of Shoreham village, there is a limestone ledge called Mutton Hill, and here several Lower Silurian formations are distinguishable by their fossils. The rocks, in the words of Mr. Wing, have the following ascending order:

1. Light gray even-bedded sandstone, in beds six inches to two or three feet thick; six or eight feet at the top, honeycombed with *Scolithus linearis:* Potsdam. 310 feet.

2. Dark iron-gray, feebly calcareous sandstone or quartzyte, with *Fucoids:* Upper Potsdam? 200 feet.

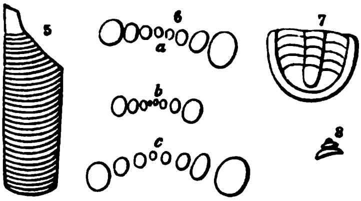
3. Subcrystalline limestone, containing a small *Orthoceras* and Encrinal disks: Lower Calciferous. 20–25 feet.

4. Dark greenish, fine-grained sandstone, the lower twelve or fifteen feet perforated with small *Scolithi* (*S. minutus*), the rest interstratified with dolomitic limestones, holding *Ophileta compacta*, *O. complanata*, (hence called the *Ophileta beds*), a few other species of convoluted shells including two or three *Maclureæ*, a small *Orthis* (*Orthisina*), a *Trilobite*, etc.: Calciferous. 300–400 feet.

No. 1 is at the western base of Mutton Hill and No. 4 is its geological top.

In a second fold or anticlinal, Nos. 1, 2, 3 and 4 again come up; and No. 3 is more than 200 feet thick and holds a number of small *Orthocerata*, two species of *Gasteropods*, including a *Maclurea* and a *Bathyurus*. The accompanying figures by Mr. Wing serve to sustain his statements. Figure 5, an *Orthoceras* apparently the Calciferous species, *O. primigenium;* 6, sections of *Maclureas;* 7, pygidium of a *Bathyurus*; 8, shell resembling a *Holopea*.

5–8.



In this "second fold," No. 4, or the "Ophileta beds," *Scolithus minutus* and the Fucoid *Palæophycus arcuatus* are abundant.

In the same fold, above No. 4, appears No. 5, called the "*Trilobite bed and Conglomerate.*" It consists below of dark bluish sandstone or quartzyte with green slaty seams containing Fucoids; then ten or fifteen feet of siliceous limestone, holding a few small *Trilobites* and other fossils; then a conglomerate made of flat and rounded pebbles from the quartzyte below—the flat ones one to two inches across, the rounded, from coarse shot to large bullets; the paste sometimes limestone; the slaty seams holding toward the bottom a small *Orthis* (*Orthisina*), a small *Trilobite*, and, near the top, *Maclurea sordida* and *M. matutina* in crowded abundance at some places. This "conglomerate may generally be traced along the west side of the great slate belt without aid from its fossils."

At Bascom's Ledge, which is the "fourth fold" going eastward from Mutton Hill, Nos. 1, 2, 3, 4 and 5 occur, with their fossils, and the lower part of No. 5, the "Trilobite" or "Conglomerate" bed exists in great force. The Trilobites (*Asaphus*, etc.), and other fossils mentioned on page 341 are from this bed, ten or twelve feet of it being made up almost entirely of them. There is also above the "conglomerate," No. 6, the "Rhynchonella beds" already mentioned—so called from "real or supposed *Rhynchonellæ* found in the next (5th) fold." This No. 6 is a nearly pure, or feebly siliceous, or dolomitic limestone, finer in grain and softer than the formations below, generally weathering to some shade of yellow, red, pink, or buff; and is without fossils in the line of section of the 4th fold.

Over No. 6 occurs No. 7, the *Sparry Limestone*, 400 to 600 feet thick; and No. 8, the slate of the great belt, here perhaps 300 or 400 feet thick. The Sparry Limestone is the stratum that, one and a half miles northeast of Orwell village, afforded the *Receptaculites Neptuni*, "which seemed to prove" its Trenton age; and is the Sudbury rock affording *Trinucleus*. The *slate* would consequently be the Hudson River slate.

The formations above recognized are, briefly, as follows:

1. Sandstone.—*Potsdam*.
2. Iron-gray calcareous sandstone.—*Upper Potsdam*.
3. "Subcrystalline limestone," part of the "Eolian Limestone" containing *Orthoceras*, etc.—*Lower Calciferous*.
4. "Ophileta beds," part of the "Eolian Limestone."—*Calciferous*.
5. "Trilobite bed" and "Conglomerate," part of the "Eolian Limestone."—*Quebec Group*.
6. "Rhynchonella beds" with the "striped stratum," part of the Eolian Limestone.—*Chazy*.

7. "Sparry Limestone," part of the "Eolian Limestone."—*Trenton.*

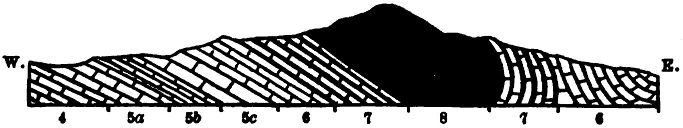
8. The slates of the "great central belt."—*Hudson River Slates* (or, Cincinnati group).

5. *Northern Cornwall, Middlebury, Weybridge.*

Weybridge is the next town north of Cornwall, and Middlebury lies to the east of Southern Weybridge and Northern Cornwall. The area of the Eolian limestone includes both towns on the Vermont Geological Map.

Ellsworth Ledge is situated in North Cornwall, two and a half miles northeast of "Bascom's Ledge," and two or three miles west of Middlebury. It is Mr. Wing's *fifth* fold. The "great central slate belt," instead of stopping in Cornwall as represented on the Vermont Geological Map, continues on, as a narrow belt, and part of the way a double belt, to middle Weybridge.

9.



Mr. Wing's section from west foot of Ellsworth Ledge, in Cornwall, to Middlebury on the east.

Commencing at the western base of Ellsworth Ledge (see the accompanying section from Mr. Wing's notes) there is no outcropping Lower or Upper Potsdam, and No. 3 also is wanting; the first formation is No. 4, the "Ophileta beds" with their fossils; next No. 5, *a*, *b*, *c*, the "Trilobite bed" and those associated; next No. 6, the "Rhynchonella beds," with fossils; then No. 7, or the "Sparry Limestone," with fossils, this and the preceding of unusual thickness; and No. 8, the Hudson River slate.

Overlying the "Conglomerate bed" (No. 5 *b*) there is a bed of coarse limestones, (5 *c*) 100 or 200 feet thick, holding obscure convoluted shells (*Maclurea ?*), a large *Orthoceras* and *Murchisonia*, and *Bathyurus Saffordi*, a species characteristic of the Quebec group.

Above this stratum come the "Rhynchonella beds," (No. 6) perhaps 300 to 400 feet thick, containing, in a "striped stratum" characteristic of it, *Rhynchonellæ* (?) in great abundance, pygidia of *Asaphus canalis* and of one or two other species of *Asaphus*, pygidia of *Bathyurus Angelini*, a Chazy species in Canada; also species of *Maclurea*, *Orthis*, *Leperditia* (a small hand specimen containing them by the thousands), *Encrinal stems*, etc. This "striped stratum," twelve to fifteen feet thick, is overlaid by an inch or so of a dark slaty sandstone and then by a stratum of white limestone (weathering yellow) six to twelve inches thick. These "Rhynchonella beds" are without much doubt Chazy in part; the upper part may be Birdseye and Black River. Since the Birdseye and Black River do certainly exist in Orwell and half a mile east of Shoreham village, there is not much doubt that they exist here also.

The "Sparry limestone" does not here afford fossils. The age of the rock is inferred from the fossiliferous beds farther south in similar position in Cornwall, Sudbury, Hubbardton, the facts respecting which have been already mentioned. "Trenton fossils occur also in Benson, and on the same strike in Whitehall, New York;" so that "it is no longer to be doubted that the Trenton limestone does exist in long bands stretching down on the west side of the two belts of slate from Weybridge southward."

At Weybridge Upper Falls, on the right bank, the "Rhynchonella beds" occur west of the slate, beneath the "Sparry limestone;" and the "striped stratum," which is partly cut through by the stream, is full of fossils, as first observed in 1867; and the species are the same *Rhynchonellæ* and convoluted shells that were found in the "Rhynchonella beds" west of the slate in Cornwall—a fact which makes the two beds identical in age. On the south side of the Falls occurs *Retepora incepta*. This makes the beds to be of the age of the Chazy, and proves that the Chazy formation has a wide range, the beds in Cornwall affording *Asaphus canalis*, *Bathyurus Angelini*, *Leperditia*, etc., as already stated. "No marble quarries in Addison county have been wrought in the Quebec Group; all are now wrought in the Chazy and formations above it, or in the sheet of limestone at the bottom of the Calciferous."

In Middlebury, the "Sparry limestone" affords "very large and conspicuous *Encrinal stems;* they occur mostly near the slate, like the few other fossils of this slate." The formation is a continuation of that of East Cornwall.

The limestone bordering the "central slate belt" on the east, is the same formation with that on the west. This has been proved by the fossils, as already stated. It is also shown by the fact that this main belt of slate, which extends south from Weybridge to join the wider belt of the southwestern part of the State, is wholly cut off by limestone in the north part of Sudbury, the cut being 40 or 50 rods wide, as stated on page 339. "The limestone at the break is certainly not lower than the Chazy and Trenton, and it is continuous with the fossiliferous Trenton limestone of Sudbury on one side, and with that of Otter Creek valley on the other; and hence the limestones on the east of the slate, in Otter Creek valley, must be of the same age as those on the west."

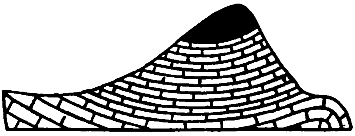
Moreover, other facts give us the age of the slates. "For the limestones at the northern terminus of the slate seem to dip down around *under* the slate. The limestones on the west dip eastward beneath the slate, and so do the slates and limestone beds on the east, the slate being an inverted synclinal and the limestones abraded anticlinals. Indeed, one of the folds of the slate shows the limestone continuing around under the synclinal axis of the slate." "The evidence is plain that the slates are decidedly the more recent." Moreover, thin beds of limestone in the slate actually contain Trenton fossils (p. 339).

The fact that the slates overlie the limestone, and are therefore Hudson River slates, is further shown in the direct and nearly horizontal superposition of the latter by the former in several high summits south of Rutland, as in Mount Dorset or Eolus in the town of Dorset; Danby Mountain, on the borders of Danby and Dorset, just north of Eolus; Equinox Mountain, in the town of Manchester, the town next south of Dorset; in Spruce Peak, in Arlington, to the southwest; in Mount Anthony, in Bennington, farther south; and in Graylock, in northern Berkshire, in Massachusetts.

The Vermont Geological Report mentions, on the authority of determinations by Professor Hall, the occurrence in the Eolian limestone of a species of *Euomphalus* in Sudbury and also in Whiting; of a *Zaphrentis* in Sudbury, and also in Cornwall, along with species of *Euomphalus* and *Chætetes*; of *Stromatopora* in Sudbury, Orwell and Cornwall, and in East Middlebury, Brandon, New Haven and Williston; of large *Encrinal stems* in Sudbury and Cornwall; of a species of *Stictopora* "remarkably well defined" in Sudbury.

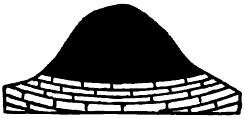
The Vermont Report gives also the particulars with regard to the stratification in the above mentioned mountains, with sectional views of some of them, which are here reproduced. Mount Eolus (fig. 10), 3,148 feet above the sea-level, has a cap of hydromica slate, about 500 feet thick (498 feet, Vt. Rep., p. 412), overlying in a very shallow synclinal 1,960 feet of Eolian limestone.

10.



Mt. Eolus, Dorset.

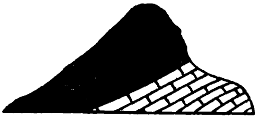
11.



Spruce Peak, Arlington.

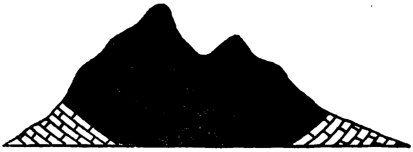
Danby Mountain is a continuation northward of the same mountain, with the same structural conditions, but with the slate, "according to a rough trigonometrical calculation" (Vt. Rep., p. 433), 1,354 feet thick. In Mt. Equinox, which is 3,872 feet in height, according to Guyot, the limestone rises "as high perhaps as in Mt. Eolus." In Spruce Peak, Arlington (fig. 11), the slates, almost horizontal but in a shallow synclinal, constitute the larger part of the height, and overlie about 300 feet of limestone. In the Bennington Mountain, Mt. Anthony (fig. 12), 2,688 feet high, the Eolian limestone makes the base, and over it are about "1,800 feet of shales and schists." dipping westward on the east side, and slightly eastward on the west side. In Graylock (fig. 13), having a height of 3,505 feet, the structure is like that of the mountains just described. The section of the mountain here given, copied from the Vermont Report, is that published by Prof. Emmons. My own observations in the region, undertaken under the idea that Prof. Emmons's view was wrong, ended in proving him right. Over 2,000 feet of slates overlie the limestone.

12.



Mt. Anthony, Bennington.

13.



Graylock.

Again, the occurrence of isolated north-and-south belts or ledges of limestone within the "great central slate belt"—as for example, those of West Rutland, Ira, Castleton, Hubbardton, Sudbury—suggests, first, that the slate where broadest is not one synclinal, but one with several subordinate anticlinals and synclinals; and, secondly, that the limestone was brought up to the surface from beneath by means of the anticlinals.

It remains to give an account of the fossils and stratification of the limestone and quartzyte of North Middlebury and New Haven; of the eastern belt of quartzyte and the bordering limestone; and of the great fault at Snake Mountain, west of Middlebury; and to present the general conclusion deduced by Mr. Wing from his observations.

(To be continued.)

ART. XXXIX.—*Notes on the History of Helianthus tuberosus, the so-called Jerusalem Artichoke;* by J. HAMMOND TRUMBULL and ASA GRAY.

UNDER this heading the Botanical Editor of the Journal proposes to offer a few explanatory remarks, introductory to the subjoined letter which he received from Mr. Trumbull in answer to a recent enquiry.

Linnæus, in the Species Plantarum, gave to *Helianthus tuberosus* the "habitat in Brasilia." In his earlier *Hortus Cliffortianus* the habitat assigned was "Canada." M. Alphonse

DeCandolle, in his *Géographie Botanique*, ii, 824, (1855), refers to this as "decidedly an error, at least as to Canada properly so called," assigns good reasons for the opinion that it did not come from Brazil, nor from Peru (to which the name under which it appeared in cultivation in the Farnèse garden seemed to refer), but in all probability from Mexico or the United States. He adds that Humboldt did not meet with it in any of the Spanish colonies.

About this time I received from my friend and correspondent, the late Dr. Short of Kentucky, some long and narrow tubers of *Helianthus doronicoides* Lam., with the statement that he and some of his neighbors found them good food for hogs, and, if I rightly remember. had planted them for that purpose. They were planted here in the Botanic Garden; after two or three years it was found that some of the tubers produced were thicker and shorter; some of these were cooked along with Jerusalem artichokes, and found to resemble them in flavor, although coarser. Consequently, in the second edition of my *Manual of the Botany of the Northern United States* (1856), it is stated that *H. doronicoides* is most probably the original of *H. tuberosus.* This opinion was strengthened year after year by the behavior of the tubers, and by the close similarity of the herbage and flowers of the two plants, as they grew side by side; indeed, as the two patches were allowed to run together in a waste or neglected place, they have become in a measure confounded. Wishing to obtain an unmixed stock, I applied last autumn to Prof. J. M. Coulter of Hanover, Indiana, and received from him a good number of tubers from wild plants of the neighborhood, which will now be grown. Some of these were slender, some thicker and shorter, and a few were to all appearance identical with Jerusalem artichokes. If they were really all from one stock, as there is reason to believe, the question of the origin of *Helianthus tuberosus* is well nigh settled.

We were now interested to know whether our Indians—at least those of the Mississippi Valley, where *H. doronicoides* belongs,—were known to cultivate these tubers or to use them for food. Recently a note in the American Agriculturist called attention to a sentence in Dr. Palfrey's History of New England, i, 27, stating that the Indians of that region raised, among other articles of food, "a species of sunflower, whose esculent tuberous root resembled the artichoke in taste." The venerable historian found himself at the moment unable to refer me to the sources of this statement; but, as it was now certain that some record of the kind existed, I applied to Mr. Trumbull, who obligingly and promptly supplied the information required, and placed it at my disposal in the following letter:—

HARTFORD, CONN., March 26, 1877.

My dear Prof. Gray:—I cannot refer you to the authority (*totidem verbis*) for Dr. Palfrey's statement that the Indians of New England cultivated "a species of sunflower whose esculent tuberous root resembled the artichoke in taste," but there can be, I think, little doubt of the *fact*. The historical evidence that "artischoki sub terrâ" were cultivated in Canada and in some parts of New England before the coming of Europeans is tolerably clear. The only question, if there be any, is as to *species*, and this does not appear to have been raised for more than half a century after the "Jerusalem artichoke" was known to English and Continental botanists.

I can discover no authority whatever, before 1700, for ascribing to the *Helianthus tuberosus*, either a Brazilian or a Mexican origin, except—and the exception is unimportant—in C. Bauhin's identification (in his *Pinax*, 277) with "Helianthemum Indicum tuberosum" (H. tuberosus, L.), of a plant that he had described in his earlier *Prodromus* (ed. 1671, p. 70) as "Chrysanthemon latifolium *Brasilianum*," from a dried specimen sent to him "eo nomine" from the garden of Contarini.

The first trace I find of this species, in Europe, is in the 2d part (cap. 6) of Fabio Colonna's "Ecphrasis minus cognitarum stirpium," published at Rome in 1616. He described it from a plant growing in the garden of Cardinal Farnese. The sunflower was already well known to European botanists, and had been described and figured by Dodoens (1563) and Lobel (1576) as "Chrysanthemum *Peruvianum*" and "Flos solis *Peruvianus*." With reference to these descriptions, probably, Colonna gave the new species the name of "Aster *Peruanus*, tuberosâ radice," otherwise "Solis flos Farnesianus." (He gave a more particular description of the plant in his annotations to Recchi's Hernandez, Plant. Mexic. Hist., 1651, pp. 878, 881, as "Peruanus Solis flos ex Indiis tuberosus.")

The author of the "Descriptio variorum plantarum, in Horto Farnesiano," published under the name of Tobias Aldinus (Rome, 1625), gave some account of the *roots*, which he calls "Tubera Indica," of the "Solis Flos tuberosus, seu Flos Farnesianus Fabii Columnæ" (p. 91). It may be observed, that several of the rarer plants in the Farnese garden, at this time, were from "Canada" and "Virginia." The Passion Flower (admirably figured by Aldinus) is described under its *Virginian* name, "Maracot" (the "Maracocks" of John Smith and Strachey); and a "Campanula Americana" is otherwise named "Campanula Virginiana, seu ex Virginiis insulis."

C. Bauhin, in his Pinax (first published in 1623), ed. 1671, p. 276, notes that the "Helianthemum Indicum tuberosum" is called "Chrysanthemum è *Canada*, quibusdam. *Canada* et *Artischoki sub terrâ*, aliis. *Gigantea*, Burgundis."

P. Laurenberg, *Apparat. plant.* (Rostock, 1632), names the species, "Adenes *Canadenses* or Flos Solis glandulosus." Ant. Vallot, *Hortus Regis Paris.*, 1665 (as cited by Bauhin) gives the names "*Canada* and *Artischoki* sub terrâ," and "*Canadas*," and describes, also, "Helenium Canadense altissimum, *Vosacan* dictum," which Tournefort distinguishes as "Corona Solis *rapunculi radice*" (Inst. Herb. 490), and which became *H. strumosus* L. "Vosacan," by the way, is a French fashion of writing the Algonkin word *wassakone* or *wassakwân*, which means a 'bright yellow flower.' The modern Chippeways give this name to the flowers of the pumpkin and squash.

Under whatever name the Jerusalem Artichoke was described, there seems to have been a general agreement among European botanists that it came from Canada. F. Schuyl, *Catal. Horti Lugd.* Bat. (Heidelberg, 1672), varies the specific name to "Chrysanthemum *Canadense Arumosum.*" P. Amman, *Charac. Plant. Nat.* (1676), has "Helenium Canadense."

It was introduced to England about 1617. In that year, Mr. John Goodyer, of Maple Durham, Hampshire, "received two small roots thereof, from Mr. Franquevill of London," which were planted, and enabled him, before 1621, to "store Hampshire." He wrote an account of the plant, under date of October 17, 1621, for T. Johnson,—who printed it in his edition of Gerard, 1636 (p. 753). Before this the species had been figured and described by J. Parkinson, in *Paradisus Terrestris* (London, 1629), as "Battatas de *Canada*," and in his *Theater of Plants*, 1640 (p. 1383), he has the figure—a good one—without the description, under the names "Battatas de Canada, the French Battatas, or Hierusalem Artichoke." Johnson, in Gerard (p. 753), refers to Parkinson's description, and gives the name as "Flos Solis Pyramidalis, Jerusalem Artichoke." It already grew "well and plentifully in many parts of England."

The notices by early voyagers, of ground-nuts, eaten by the Indians, are generally so brief and so vague, that it is not easy to distinguish the three or four species mentioned under that name or its equivalents. The *Solanum tuberosum*, *Apios tuberosa*, *Aralia trifolia*, and a *Cyperus* (*articulatus ?*) were all "ground nuts," or "earth nuts." We find, however, in a few instances, unmistakable mention of the roots already known in Europe as "Canadian."

Brereton, in his account of Gosnold's voyage to New England in 1602, notes the "great store of ground nuts" found on all the Elizabeth Islands. They grow "forty together on a string, some of them as big as a hen's egg" (Purchas, iv, 1651). These, doubtless, were the roots of *Apios tuberosa*. But when Champlain, a few years later (1605–6) was in the same region, he observed that the "Almouchiquois" Indians near Point

Mallebarre (Nauset harbor, probably,) had "force des racines *qu'els cultivent*, lesquelles *ont le goût d'artichaut*" (Voyages, ed. 1632, p. 84). And it is to these roots, evidently, that Lescarbot alludes, *Histoire de la Nouv. France*, 1612 (p. 840): there is, he says, in the country of the Armouchiquois (i. e., New England, west and south of Maine,) a certain kind of roots "*grosses comme naveaux*, très excellentes à manger, ayans *un goût retirant aux cardes*, mais plus agréable, *lesquelles plantées multiplient* en telle façon que c'est merveille;" and he thinks these must be the "Afrodilles" described by Pliny.

Sagard-Theodat (*Hist. du Canada*, 1636, p. 785) mentions the cultivation of the sunflower, by the Hurons—who extracted oil from its seeds,—and names also the "roots that we [the French] call *Canadiennes* or *Pommes de Canada*, and that the Hurons call *Orasqueinta*, which are not very (assez peu) common in their country. They eat them raw, as well as cooked, as they eat another sort of root resembling parsnips [Sium lineare?], which they call *Sondhratates*, and which are much better; but they seldom gave us these, and only when they received some present from us or when we visited them in their cabins." He goes on to speak of "patates, fort grosses et très-excellentes," some of which he had obtained from an English vessel captured by the French; but none of these were to be found in the Huron country, nor could the Indians tell him the name of them; and he regretted that he had not brought some with him, for planting, since "this root, being cut in pieces and planted, quickly grows and multiplies, it is said, *like the pommes de Canada*" (pp. 781, 782). It is plain that the Huron roots first-mentioned were, or that Sagard believed them to be, 'Jerusalem Artichokes,'—already known as "Canadian."

I find no mention of the artichoke in Virginia, or the southern colonies, before it was cultivated by Anglo-Americans. The author of "A Perfect Description of Virginia," printed in 1649, says that the English planters have (inter alia) "roots of several kindes, Potatoes, Sparagus, Carrets, ... and Hartichokes." Beverly, (Hist. of Virginia, 1722, p. 254), mentions "Batatas Canadensis, or Jerusalem Artichoke," as planted by some of the English, for brewing beer. Yet, the *name* of one of the esculent roots mentioned by Hariot (Brief and True Report, etc., 1585) *ought* to belong to some species of 'Sun Flower'—and if to any, to *H. tuberosus*. Hariot names three tuberous roots found in Virginia: "*Openauk*, a kind of roots of round form, some of the bignes of walnuts, some far greater, which are found in moist and marish grounds growing many together one by another in ropes, or as though they were fastened with a string. Being boiled or sodden, they are very good meate." [C. Bauhin (Prodromus, 89) identifies these with "Solanum tuberosum esculentum,"—and has been followed by later writers. The description seems to me to indicate *Apios tuberosa.*] "*Kaishucpenauk*, a white kind of roots about the bignes of hen egs and nere of that forme: their taste was not so good to our seeming as of the other, and therefore their place and manner of growing not so much cared for by vs: the inhabitants notwithstanding vsed to boile and eat many." These *may* be 'Virginia potatoes,' but their *name*, if Hariot recorded it correctly, means '*Sun*-tubers.' The etymology is perfectly clear. The other roots described by Hariot, "*Okeepenauk* are also of round shape, found in dry grounds: some are of the bignes of a man's head," etc. These must be the "Tubera terræ maxima," of Clayton, "vulgo *Tuckahoo*," which Gronovius (Fl. Virgin., 205) refers to *Lycoperdon solidum* L., and for which Rafinesque (Med. Fl. ii, 270) proposed a new genus "Tucahus." Kalm describes them (Travels, i, 225) as "Truffles." Fries (El. Fung. ii, 39) assigns them to his *Pachyma cocos.*

Writing in haste and with frequent interruptions, it has been possible to do little more than copy, without condensing or arranging, such notes as I had before me. They have extended to such a length that I must not add even an apology for the superfluous matter. Yours truly,

J. H. TRUMBULL.

It would be interesting to know whence came the French name of these Helianthus tubers, "Topinambour," it being the only thing in the case which, as Mr. Trumbull remarks, "looks to a Brazilian origin, as it seems to be derived (and so Littré gives it) from the Topinamboux Indians of Brazil." The English name, "Jerusalem Artichoke," comes, as is well known, from the Italian *Girasola*, i. e., sun-flower.

As to the annual sunflower, or *Helianthus annuus*, said by Linnæus to come from "Peru" and "Mexico," I have for some years been convinced that its original is the *H. lenticularis* of Douglas, which again is probably only a larger form of *H. petiolaris* of Nuttall, natives of the western part of the Mississippi Valley and of the plains to and beyond the Rocky Mountains. It is an interesting confirmation of this opinion, that Sagard (as mentioned in the above communication) and Champlain found this sunflower in cultivation by the Huron Indians, for the sake of the oil of its seeds, which they used for hair-oil.

ART. XL.—*A new Investigation of one of the Laws of Friction*; by A. S. KIMBALL, Professor of Physics in the Worcester Institute of Industrial Science.

REULEAUX, in the appendix to his recently published "Cinematics of Machinery," says that "many engineering schemes have failed because they were designed in accordance with the statements given in our text-books as the laws of friction." He furthermore adds, "that it is time that the experiments of Bochet and Hirn should be raised from their place as foot-notes to a position in the text."

During the last year, I have conducted experiments, on as extensive a scale as our laboratory would allow, for the purpose of settling, if possible, certain contested points in the doctrine of friction.

Our manuals of mechanics, following Morin and Coulomb, say the coefficient of friction *does not vary with the velocity.* Bochet says that it *decreases as the velocity increases.* Hirn says that it *increases as the velocity increases.* Contradictory as these statements are, it is probable that each contains a partial truth. They need to be combined to make a complete statement.

The results of my experiments, which this paper is to describe, would indicate that the following is the true law, within the range of my experience. The coefficient of friction at very low velocities is small; it increases rapidly at first, then more gradually as the velocity increases, until at a certain rate, which depends upon the nature of the surfaces in contact and the intensity of the pressure, a maximum coefficient is reached. As the velocity continues to increase beyond this point, the coefficient decreases. An increase in the intensity of the pressure (the number of pounds on a square inch), changes the position of the maximum coefficient, and makes it correspond to a smaller velocity. The more yielding the materials between which the friction occurs, the higher is the velocity at which the maximum coefficient is found. Heating the rubbing bodies changes the position of the maximum coefficient to a higher velocity, since by heat the bodies are made softer, and are caused to yield to pressure with greater ease. For a considerable range of velocities in the vicinity of the maximum coefficient the coefficient is sensibly constant.

The experiments upon which I base my conclusions may be classified as follows:

(1.) Sliding friction down an inclined plane.
(2.) Sliding friction at uniform velocities on a horizontal plane.
(3.) Friction of belts on the surface of cast iron pulleys.

(4.) Friction of wrought iron journals in boxes or bearings of different materials.

(1.) *Sliding friction down an inclined plane.*—A full description of the apparatus used, and some of the results obtained, will be found in this Journal, March, 1876; also in Van Nostrand's Eclectic Engineering Journal, June, 1876. It is sufficient for my purpose to say that the sliding body was made to carry a smoked glass, upon which was traced a waved line, which by direct measurement gave the time of sliding and the spaces passed over, from which it was easy to compute the corresponding coefficients of friction. In the article referred to, no velocities less than two feet a minute were examined. An extension of the same experiment, to the case of much lower velocities, showed a curve concave toward the time line, indicating that at these velocities the coefficient of friction was increasing. As the velocities increased, the line changed its direction and became convex toward the time line; thus giving in the limits of one experiment a verification of the statements made above. For further particulars respecting this method of experiment, I refer to the article published in March of last year.

(2.) *Sliding friction at uniform velocities on a horizontal plane.*—A heavy pine plank, fifteen feet long, whose surface had been planed, was carefully leveled on the floor of the laboratory. The weight-box was mounted upon shoes which could be covered with the material experimented upon. To its forward end a spring dynamometer was attached, which was pulled by a cord wound around a drum, which was made to revolve at a constant velocity. The motive power was a fifteen horse-power Corliss engine, belonging to our machine shop, whose fly-wheel runs with great regularity at the rate of sixty revolutions a minute. A shaft from the shop runs underground to the cellar beneath my laboratory, whence through several countershafts the power is transmitted to any part of the room. By means of change pulleys, I can easily command a great range of velocities.

The experiments were made by drawing the box along the plane at various velocities, and reading the friction from the dynamometer. This combination answers very well for low velocities, but the slide can not be easily stopped when the speed is great.

Several series of experiments were made, with wood on wood, also with leather on wood. The results verify the first part of my statement, that the coefficient of friction increases with the velocity, when this is small. The following are some of the results obtained by this method of experiment.

TABLE I.—*Pine on pine. Slide loaded with* 100 *lbs. Velocity in inches in a minute.*

V.	Coefficient of Friction.
5	·19
11	·20¾
75	·24
300	·25

TABLE II.—*Leather on pine. Slide loaded with* 100 *lbs. Velocity in inches in a minute.*

V.	Coefficient of Friction.
·79	·22
1·58	·27
3·94	·33
9·98	·36
29·14	·38
72·50	·41
157·50	·43
226·80	·45
300·	·46
466·	·47½

These experiments show the increase of friction with the velocity at low speeds quite clearly; and in connection with the series published last March, which showed its decrease at high velocities, would prove the high probability of the law as I have stated it, especially since the experiment on the inclined plane has been made to show a variation of the coefficient from a low value, through a maximum, to a low value again, while the velocity constantly increases.

(3.) *Friction of belts on the surface of cast iron pulleys.*—A piece of leather belting was hung over a cast iron pulley. To one end a determined tension was given by a fixed weight; to the other end was attached a spring dynamometer. The tension of the ends of the belt being known, the coefficient of friction was easily found. Several pulleys were used, and various kinds of belting; and a considerable range of tensions was employed, with uniform results.

Two tables are here given, one selected to show the increase of the coefficient at low speeds, the other to show the existence of a maximum coefficient at a definite velocity. In the third table, the first column gives the velocity in feet in a minute; the second and third give the tensions of the ends of the belt; and the fourth gives the relative values of the coefficients found, the maximum in each case being represented by 1·00. I give relative values, since they show variations more clearly than the absolute values.

Table III.

V.	T_2.	T_1.	C.
·37	30	13	·42
·52	30	12½	·44
1·1	30	11½	·48
2·3	30	10½	·53
2·9	30	10	·55
4·4	30	9½	·58
15·4	30	6½	·78
34·1	30	5½	·86
80·3	30	4½	·96
104·5	30	4¼	·99
228·8	30	4¼—	1·00

In the following table only velocities and relative coefficients are given.

Table IV.

V.	C.
18	·82
92	·93
660	1·00
1190	·96
1980	·82
2969	·69

(4.) *Friction of wrought iron journals in boxes of different materials.*—In this course of experiments a modification of the friction brake was used. A description of the arrangement in one series will serve for all the others. A shaft 1″ in diameter was adjusted so that it could be driven at almost any rate between one revolution in two days and 1,000 in a minute. A hole was bored through a block of cast iron 3½″×3½″×1½″, and carefully fitted to the shaft; rigid iron rods were screwed into the top and bottom of this block, and adjusted to stand in a vertical line at right angles to the shaft. Upon these rods slotted weights could be placed, and thus the pressure upon the shaft and the center of gravity of the brake could be readily adjusted. Upon the front of the block a plane mirror was fastened, and before it, at a convenient distance, were placed a scale and telescope. When the shaft was turned, the friction between it and the brake caused the latter to turn until the moment of the friction was equal to that of the brake, and the angle at which this equality was established could be read from the scale by the telescope. As the center of gravity was always adjusted so that the brake never revolved through an angle of more than three degrees, the scale readings were approximately proportional to the coefficient of friction; and since relative and not absolute results were sought for, the labor of reduction was not undertaken. Several tables will be given to illustrate the method of conducting a series of experiments with this apparatus.

Table V.

Wrought iron shaft, 1″ diam.; box, cast iron, 1½″ long; load, 100 lbs.
Shaft well oiled.

Velocity of the circumference of the shaft.

	No. 1, 72″.	No. 2, 272″.	No. 3, 605″.	No. 4, 1320″.
Scale readings	515	500	...	..
	515	500	...	...
	515	495	...	...
	515	495	...	...
	515	495	...	...
	515	495	...	...
	515	...	485	...
	515	...	485	...
	520	...	485	...
	520	...	485	...
	520	...	485	...
	520	...	490	...
	525	...	...	480
	525	...	...	480
	525	...	...	480
	525	...	...	475
	525	...	...	480
	525	...	...	485
Mean	519	497	486	480
Position of equilibrium	464	464	464	464
Deflections	55	33	22	16

Relative values of the coefficient of friction.

No. 1, 1·00. No. 2, ·60. No. 3, ·40. No. 4, ·29.

The results given above were made with high velocities, and show coefficients of friction decreasing as the velocity increases.

The results of a similar series with very low speeds are given in the next table.

Table VI.

Velocity of the circumference of the shaft: No. 1, ·007″; No. 2, ·027″; No. 3, ·060″; No. 4, ·132″ in a minute.

No. 1, ·37. No. 2, ·51. No. 3, ·73. No. 4, 1·00.

These results, unlike those of the former table, show a coefficient of friction increasing as the velocity increases.

A large number of experiments similar to those given above have been made with uniform results.

I have been able to verify experimentally the law stated early in this paper in the following cases: wood sliding on wood, wood on iron, leather on iron, zinc on iron, and copper on iron; and to obtain results verifying the first half of the law in the case of leather on wood.

The experiments above detailed make it easy to explain the various results obtained by the three authorities quoted at the beginning of this paper. Morin experimented under conditions which gave him a coefficient very near the maximum, and thus his results are approximately constant. Bochet experimented with railway trains, his conditions were high speeds, hard rubbing surfaces, and great intensity of pressure. All these circumstances are favorable to the result he obtained, namely, a coefficient decreasing as the velocity increases. Hirn, on the other hand, employed very light pressures, less than two pounds on a square inch, and kept his rubbing surfaces so thoroughly lubricated that the friction was between oil and oil instead of two metal surfaces; his speeds were not very great. These conditions are precisely the ones I have found favorable to the results he reached,—a coefficient, increasing as the velocity increases. It would be very easy to form a theory which would account for the variation of friction with the velocity, under the rule I have given.

It is well known, that if a given deflection in a bar is produced by a weight acting for five seconds, for example, that the same deflection may be produced, by a less weight, acting for a longer time. Now, as the force required to overcome friction is, partially at least, expended in bending down the minute irregularities on the surface of the rubbing bodies, it becomes evident how, other things being equal, a rapid motion would call for the exertion of a greater force than would be required if the motion were slow.

On the other hand, the longer two surfaces under pressure are in contact the greater must be the interlocking of the irregularities upon the rubbing surfaces. On this account a rapid motion would not require the expenditure of so great a force to overcome the friction. Thus, we have two effects, varying with the velocity, but having opposite signs. Now it is not probable, from the nature of the case, that these effects are numerically equal, or even proportional, and thus we can, at the least, say that the conditions are favorable to the existence of a maximum resultant effect. Having, however, ascertained the fact by experiment, the explanation becomes a matter of minor importance.

It may be said that these facts have no practical importance at the velocities ordinarily employed. I would call attention to Table V, where it will be seen that by increasing the velocity of shafting within the limits of ordinary shop practice, a reduction of the coefficient of friction of quite fifty per cent may be made. The pressure on the shaft might also be reduced, for it would be unnecessary to maintain so great a tension upon the belts, and thus in some cases a very considerable economy of power might be effected. We know that in many shops a large fraction of the power developed by the engine is expended in overcoming the friction of the shafting and machinery.

On the other hand, it is desirable that the friction of the belt upon the pulley should be as great as possible. The conditions usually met with, which determine the friction of belts, are, low intensities of pressure, a rubbing surface which yields with considerable ease. In such cases a high speed is needed to develop the greatest amount of friction. See Tables III and IV.

I am under obligations to Messrs. Butterfield and Wilson, who have rendered me valuable assistance in conducting the experimental work of this investigation.

I hope soon to be able to give tabulated results, which may have a certain practical value to working engineers.

ART. XLI.—*Examination of American Minerals.* No. 6.—*Description of Columbic Acid Minerals from new localities in the United States, embracing a reclamation for the restoration of the name Columbium to the element now called Niobium. Description and analyses of Columbite, Samarskite, Euxenite, and Fergusonite, and the new species Hatchettolite, and Rogersite;* by J. LAWRENCE SMITH, Louisville, Ky.

IT is the common practice of all American chemists and mineralogists to speak of the metal which is called *Niobium* by English and continental chemists, as *Columbium.* This is eminently just, since the metal was discovered and well defined, and named columbium, forty-five years before the name niobium was given to it. The change of name was caused by a double mistake, in no way connected with the original observations in 1801 by Prof. Hatchett of England.

These mistakes arose as follows:—In the first place, Ekeberg discovered in 1802 a supposed new metal which he called tantalum, but which a short time afterward was regarded as identical with columbium; and for forty-five years tantalum and columbium were synonymous terms in all works on chemistry, although Wollaston suspected their dissimilarity; secondly, when H. Rose made his well-known exhaustive researches on the columbite of Bodenmais, he showed that this mineral contained not one but two metallic acids; one of these was *tantalum*, and the other he supposed to be a new metal which he named *niobium.**

Subsequent examination, however, convinced Rose (and his conclusions have been confirmed by others who have repeated his experiments), that the two metallic acids obtained from the Bodenmais columbite were really the original columbic acid of Hatchett, discovered in 1801, and the tantalic acid discovered by Ekeberg in 1802. Instead, however, of calling the first mentioned acid niobic acid, its original name should have been left to it. The result of Rose's researches was in fact simply the demonstration of the actual difference of columbium and tantalum; for Hatchett's discovery was clear, precise, and well made out, and has never been controverted.

This being a correct summary of the history of the composition of the columbium minerals, it is but right, just, and in accordance with chemical and mineralogical precedence, that the name given by the discoverer should replace that of niobium, which originated forty-five years later.

A point of less importance, but worthy of some consideration, is, that this element derived its name from the country in which it was discovered, it being the first and up to the present time, the only element discovered in that part of America usually named Columbia.

In addition to the above, an interesting fact connected with the minerals of this group, is, that all the varieties, save one or two, have been discovered in greater quantities and in larger crystals in the United States than in other known localities; for crystals of columbite weighing from one-half to seven kilograms have been found at or near the locality where the specimen was obtained that was sent to Hatchett, and several other localities far removed from the original one have since been brought to light. More recently, the highly interesting and rare columbate, samarskite, has been discovered in a locality in North Carolina, and already at one spot five hundred kilograms have been taken out. Among the minerals from this last locality, besides the samarskite and columbite, I have detected two new columbates, and also good specimens of euxenite. More recently, I have found columbite embedded in those remarkable crystals of green feldspar—Amazon stone—coming from El Paso County, Colorado, and which are the admiration of all mineralogists.

Besides the above, fergusonite in fine specimens, although small in size, has been found in the granite formation of Rockport, Mass. In fact, if we look at the localities of columbium minerals on the North American continent, they will be found to range from Greenland in the north to Carolina in the south, from Massachusetts on the east to Colorado on the west.

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* H. Rose still supposing that this tantalum was the same as what was known equally well as columbium.

After these remarks in reference to the restoration of the name columbium among the elements, replacing that of niobium, I will detail my researches upon the more recently discovered columbates.

Columbite from North Carolina.

This mineral has been found during the past few years at the mica mines in Mitchel County, and in Yancey County near Burnsville, in the State of North Carolina. It occurs in rocks belonging to the same epoch as those in which the samarskite was discovered, and which will be mentioned more fully when the latter mineral is described.

There is nothing peculiar or striking in the crystalline form of the mineral as found at this locality; many of the crystals that have come under my observation have been compressed and distorted, as is not unfrequently the case with minerals associated with mica. Most commonly I have seen it in irregular lumps weighing from five to one hundred grams. Several pieces have been sent to me under the supposition that they were tantalite, but in no instance have I found it to be the case, the specific gravity never exceeding 5·5 to 5·6.

The specific gravity of the columbite as obtained both for the crystals and for the massive variety is as follows:

Crystals	5·562
Massive	5·485

The analyses of both varieties show that they are chemically identical. The average of several analyses which agreed very closely, is:

	Massive.	Crystals.
Columbic acid*	80·82	80·06
Tungstic and stannic acids	1·02	1·21
Iron protoxide	8·73	14·14
Manganese protoxide	8·60	5·21
Copper oxide	trace	----
	99·17	100·62

The distinctive peculiarity of the composition of this columbite is the large amount of manganese oxide compared with that of the iron in the massive variety, it being greater than that given in the analysis of any other columbite.

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* I refer to the metallic acid in the analyses in this paper as columbic acid from the fact that the tantalic acid which accompanies it is only in small quantities, and also because none of the methods proposed for separating the two acids have given satisfactory results in my hands.

Columbite from Colorado.

Among the magnificent and gigantic crystals of Amazon-stone recently discovered in El Paso Co., Colorado—and so energetically explored by A. E. Foote—some specimens were shown me having small black acicular crystals imbedded just beneath their surface. Carefully detaching them from the feldspar, by no means an easy task, and examining the crystalline form, and subsequently the chemical composition, I found them to be columbite. A few small and well-marked crystals have been detached; the largest was a flattened, imperfect crystal, weighing one and one-half grams. Most commonly they are only in the form of black elongated specks. A small amount of the pure mineral that was separated enabled me to make out its composition, although I could not obtain enough for a very careful quantitative examination. The examination made gave a very low specific gravity; it was taken on ·600 gram, and is 5·15. Analysis of ·500 gram gave

Columbic acid	79·61
Iron protoxide	14·14
Manganese protoxide	4·61
Loss by heat	·50
	98·86

Samarskite.

A few small specimens of this rare mineral from North Carolina have been in cabinets for several years, but its exact locality and the nature of its occurrence were first made known in April, 1873, through the agency of Joseph Wilcox of Philadelphia, and subsequently by the investigations and collections made by Rev. J. Grier Ralston of Norristown. Not having visited the locality myself, I have obtained my information concerning it from the above mineralogists. It is found in Wiseman's mica mine, Greesy Creek Township, Mitchel County, near North Toe River, North Carolina. It was obtained while extracting the mica, principally in a kind of pocket in the mine, the miners calling it *black mineral*. Mr. Ralston was very active in having it collected, and in 1875, there had been accumulated about 400 kilograms of the mineral, which was brought away from the mine by him; since that time only a little of it has been taken out of the mines, but in all probability, it will be found again in more or less abundance. Prior to this discovery, the largest pieces of samarskite, found in the Ural locality, were of the size of hazel-nuts; these occur imbedded in a reddish brown feldspar.

Its geological position is in crystalline rocks, in what may be called a coarse granite; the minerals of which rock are not granular, but exist in large masses, so that in extracting the fine blocks of mica, these are readily detached from the other constituents of the granite. The samarskite is generally in close relation to the feldspar, which last, in all the specimens I have seen, was more or less disintegrated; this arises no doubt from the proximity of the samarskite to the surface, it not having been found as yet in the unaltered granite.

For some time after the discovery of this mineral, mineralogists were not agreed as to its being samarskite, no crystals having been found by which to establish its identity, and the partial analyses made not giving concordant results. This discrepancy arose, however, from the intermixture of other minerals, three of which I have detected, two of them being new.

On one occasion I took a specimen of very compact mineral, perfectly clean, and to casual observation perfectly uniform in color and texture; on breaking off a portion from one end of it and taking the specific gravity, I found it to be 5·221, which was so much lower than that of samarskite that I passed it over to my assistant for reëxamination. His results corresponded exactly with mine.

I then broke off a piece immediately contiguous to the one already examined and found its specific gravity 5·682, being that of samarskite. On examining the first piece by breaking off thin scales, I could detect that a portion of them had a very dark brown luster, produced by the mixture of some euxenite, a mineral that I have discovered pure and in all stages of mixture with the samarskite. There is no difficulty, with some little experience, in obtaining any quantity of this mineral with its usual characters.

Aspect of the finest specimens.—Intense jet black, and when broken having a large brilliant conchoidal fracture, perfect, even, and smooth, with the luster vitreous.

It is exceedingly brittle, breaking like black obsidian, with very sharp edges; any one seeing it broken for the first time would take it for black obsidian, until handled, when its weight would indicate that it was another mineral. All the pieces of pure samarskite are not equally brilliant in fracture as above described, but approach to it more or less.

Hardness.—I should say that it was 5·5 to 6, nearer 6, but owing to the brittleness of the mineral it is not easy to fix its exact hardness.

Specific gravity.—5·72.

Crystalline form.—I am indebted to Mr. Ralston for the inspection of the only specimens from which its crystalline form could be made out, and these have been thoroughly described and studied by Mr. Edward S. Dana; the examination made by this skillful crystallographer is to be found in this

Journal, March, 1876, page 201; he also first published an account of the region in which it is found, and gave an account of the associated minerals.

Composition.—This mineral from North Carolina has already been examined three times. In 1852, Prof. T. Sterry Hunt examined a small piece of the mineral, less than one gram, said to have come from Rutherford County; again, Miss Ellen H. Swallow has given a most excellent analysis of the samarskite from Mitchel Co. agreeing with those made by myself as nearly as the analyses of such a mineral can be expected to do when made on different specimens; and finally, Prof. Allen has made an analysis, which is to be found on p. 340 of Dana's Text Book of Mineralogy (March, 1877). The following are the analyses, (1) of myself, (2) of Miss Swallow, and (3) of Prof. Allen.

	(1)	(2)	(3)
Columbic acid	55·13	54·96	37·20
Tantalic acid			18·60
Tungstic and stannic acids	0·31	0·16	0·08
Yttria	14·49	12·84	14·45
Cerium oxides*	4·24	5·17	4·25
Uranium oxide	10·96	9·91	12·46
Manganese protoxide	1·53	10·91	0·75
Iron protoxide	11·74	14·02	10·90
Magnesia	trace	----	0·55CaO
Loss by ignition	·72	0·52	1·12
Insoluble residue from cerium oxide		1·25	----
	99·12		100·36

The late Heinrich Rose, in describing the samarskite of Miask, gives an analysis by Finkener and Stephans,† which differs from the analysis previously made, as well as from those now detailed, indicating the presence of four per cent zirconia, and six per cent of thoria. The announcement of the presence of the latter named oxide has been one of the causes of the delay of my publishing this paper, for I desired if possible to verify the results of Finkener and Stephans It is only recently that I have obtained a few grams of pure Miask samarskite, from the School of Mines of St. Petersburg, through Prof. Norpé, but all of this, except about 1½ grams, was lost after reaching me, so I have not been able to do more than make an imperfect examination; and this examination shows that there is some difference in the earthy oxides from those in the North Carolina specimens, the exact determination of which I must postpone for some future occasion.

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* I record these oxides as cerium oxides, but I am not altogether satisfied in regard to their true nature and proportion of the respective oxides, which are now undergoing a chemical examination.

† Verhandlung. Min. St. Pet., 1863, 13.

Euxenite.

In examining portions of the samarskite, that was surrounded by decomposed feldspar, I detected a mineral not having the intense black of the samarskite, but of a brownish color with a streak and powder much lighter than that of samarskite; and in pushing my researches further, the mineral was obtained still lighter, of a hair brown color, the powder being of an ash color. In thin fragments it is translucent; the fracture is subconchoidal, but in most instances irregular, with a resinoid luster.

Its aspect made it very evident that it was something different from the samarskite, and an examination proved this opinion correct, and established its true mineralogical position.

No crystals have been found, so it is not possible to establish its identity in crystallization with euxenite; but all its other physical and chemical properties are those of that mineral.

The specific gravity of pieces taken from different specimens was respectively 4·593, 4·620, 4·642. On analysis it was found to contain

Columbic acid	54·12	Uranium oxide	9·53
Tungstic and stannic acid	·21	Manganese protoxide	·08
Yttrium and cerium oxides	24·10	Iron protoxide	·31
Lime	5·53	Water	5·70
			99·58

The columbic acid was tested most carefully for titanic acid, both by fusion with bisulphate and with carbonate of potash, but none of it could be detected; only 5 milligrams of a residue was obtained as a result in these analyses, and it is well known to analysts that this is most probably attributable to columbic acid.

I need hardly insist that the above properties belong to the mineral euxenite; they approaching closely that from Tromoen, analyzed by Strecker, except, that this chemist makes as much as sixteen per cent of the metallic acids to be titanic acid. This euxenite represents a purer type of a columbate than most of those of which analyses are given, while it is also remarkable for the small quantity of iron oxide in it; being a hydrated columbate of yttria, uranium and lime.

Hatchettolite—a new Columbate.

This is an additional one of the series of columbic acid minerals found with the samarskite of North Carolina. My attention was first called by Mr. Ralston to some octahedral crystals that he had diligently uncovered from the disintegrated feldspar, which had to all appearance some connection with the samarskite. He had sent two or three of these crystals to Edward S. Dana some time before, and this last mineralogist was inclined first to refer it provisionally to pyrochlore, but finally on account of its high specific gravity suggested its possible relation to microlite. (See this Journal, March, 1876, page 204). No further steps having been taken to settle the character of this mineral, I undertook its examination on specimens furnished me by Mr. Ralston, and also on a specimen I afterward found in carefully examining the altered gangue of the samarskite in my possession.

The result has been the establishing of a new mineral of this series, which I have called Hatchettolite, from the discoverer of the element columbium. It occurs in regular octahedrons, but of the six crystals that I have examined, all have the cubic planes and the form 3-3, and E. S. Dana observed the same on the crystals he examined.

In referring to these modifications, I would state that, among eight or ten crystals of pyrochlore seen by me I have never observed them, although this last mineral is found with them, as may be seen in M. Kokscharow's magnificent work on Russian minerals. I could not detect any distinct cleavage. Its hardness is about 5; perhaps a little over. Specific gravity: that of a fine small crystal was found to be 4·851; of small fragments well selected from a large crystal that had mica in some part of it, 4·785. Prof. Brush obtained (as quoted by E. S. Dana) 4·794.

It is well to add here the specific gravity of a very fine crystal of pyrochlore, weighing one and one-half grams; as taken by myself, it is 4·25. That of microlite—another octahedral columbate,—by Shepard and Hayes, is 5·484.

Color of Hatchettolite.—Yellowish brown with a grayish opalescence; on heating to redness becomes of an opake greenish yellow; luster resinous; fracture subconchoidal.

Composition.—I made three analyses, the first two on fragments from the specimens of Mr. Ralston, and the third from a specimen in my own collection. The mineral was broken into pieces from 2 to ½ mm. in diameter, and then carefully selected under the glass to avoid admixture of any other mineral. Thus selected it was found to contain:

Columbic acid	66·01	67·86	67·25
Tungstic and stannic acids	·75	·60	·91
Uranium oxide	15·20	15·63	16·01
Lime	7·72	7·09	7·11
Yttria and cerium oxide	2·00	·86	·64
Iron protoxide	2·08	2·51	2·12
Potash	·50	1·21	not estimated
Water—lost by heat	5·16	4·42	5·02
Lead	trace		
	99·42	100·18	99·06

It will be seen that the special difference between this mineral and pyrochlore is that its predominating base is uranium oxide, which last mineral, according to Wöhler's analysis of that from Miask, does not contain any of this oxide, though the analyses of others give a small quantity of it. It is to be supposed that Wöhler examined the best and purest type of the mineral in that from Miask.

Rogersite, a new columbate.

On some of the samarskite, but more especially on the euxenite, a white crust was found adhering with some degree of firmness, and on examining it under the glass, it presented a mammillary structure, sometimes like little pearly beads. When on the euxenite it is more readily separated than when on samarskite. By pressing on it with a sharp point, it becomes detached in small fragments.

I have called this mineral Rogersite, in honor of the American geological Nestor, Wm. B. Rogers, whom we all delight to honor for his important labors in scientific and economic geology, from an early date up to the present day.

The quantity that has as yet been discovered is very small. Mr. Ralston possesses the finest specimen, which is about the size of the hand, with four or five grams of this mineral on the surface, quite pure and very characteristic. I had to operate on a great number of small pieces carefully detached, which have enabled me to establish its true character.

It is readily recognized by its well marked mammillary structure even when the fragment is quite small. Its hardness is about 3·5; specific gravity 3·313.

I made two analyses, each time on small portions. The results furnished were:

Water	17·41	16·34
Columbic acid	18·10	20·21
Yttria, etc.	60·12	

In the second analysis, owing to an accident, the yttria was lost; the first also shows about 4 per cent not accounted for.

These analyses are to be taken only as approximative, for before complete and reliable analyses of this mineral can be made, a larger quantity will be required The mineral is an interesting one, as being the first columbate discovered so largely hydrated. It has evidently resulted from the decomposition of either samarskite, or euxenite, or both.

Fergusonite.

Two years ago a dark brown mineral, with a remarkably bright and perfect conchoidal fracture, was shown to me by Mr. W. E. Knowlton of Boston, who obtained it from the granite quarries of Rockport, but its nature had not been determined. The quantity then found was very small and only a portion of it was given to me; a short time afterward, I informed Mr. Knowlton that it was fergusonite, and requested him to look further for specimens. Since then but little more has been found, but enough was furnished me to make out its true character, both physically and chemically, except its crystalline form. It is found particularly at one locality near the intersection of two trap dykes.

For a space covering about thirty or forty feet, masses of feldspar and quartz replace the granite, and it is in the feldspar that the Fergusonite is found, intimately associated with cyrtolite, and sometimes even penetrating crystals of this last mineral. In the same feldspar, annite, cryophyllite, and fine crystals of smoky quartz are found.

The mineral is of a fine dark brown color in the interior, with a clear conchoidal fracture; resinous luster;* hardness 6; specific gravity 5·681; streak light brown; powder, ash-colored; but when heated to a bright red heat for fifteen minutes changing to a light greenish yellow color with a loss of 1·50 per cent.

Columbic acid	48·75
Yttria	46·01
Cerium oxides	4·23
Iron and uranium oxides	·25
Water (loss by heat)	1·65
	100·89

It corresponds very nearly in composition with the fergusonite from Greenland.

Remarks as to the chemical character of the minerals described.

The compositions of the columbates from the various localities appear at first sight to be very complex and irregular, but if examined critically, and due allowance be made for the intermixture of these minerals, which intermixture cannot be detected on account of the similarity of color and fracture of the different minerals, this irregularity disappears to a greater or less extent.

The first, and the one best known, *columbite*, is well recognized as a simple columbate of iron and manganese.

Microlite, from what little we know of its composition, appears to be a columbate of lime. *Pyrochlore* is to be regarded as a columbate of the cerium oxides and lime; whether or not a neutral columbate, further examination is to determine.

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* The action of a red heat on small fragments is to change their color to a greenish yellow; but before this takes place, the fragments exhibit the phenomenon of glowing in a manner more striking than any specimens of gadolinite, a mineral remarkable for its glowing, that I have experimented with. From lack of material I did not take the specific gravity after heating.

Hatchettolite is doubtless a neutral columbate of uranium oxide and lime. Then, when we pass to the *samarskite*, we have a basic columbate of iron, uranium and yttrium oxides. *Yttrotantalite* and *euxenite* are basic columbates, the former anhydrous when pure, the latter hydrated, both being basic columbates of yttria and uranium oxides.

Fergusonite is a hydrous basic columbate of yttria; and *Rogersite* is a hydrated columbate of yttria, still more basic.

In making this general review of these minerals, of course I have not regarded those variable constituents existing in small quantities and replacing more or less one or other of the preponderating bases of each species.

The analysis and chemical study of the above Minerals.

I have several points under this head to consider and to describe in detail; but it more properly belongs to another paper, which will supplement this, for I am now studying the earthy oxides associated with the yttria of the North Carolina minerals, which I am far from being satisfied contains cerium oxide, although some of the reactions of cerium oxide are obtained, a fact already mentioned in a note to the description of samarskite. I am separating the earths from one kilogram of the mineral, which when obtained will furnish material enough for the proper solution of this question.

ART. XLII.—*On the Sensitiveness to Light of various Salts of Silver*; by M. CAREY LEA.

SALTS of silver may exhibit sensitiveness to light in three several ways. They may exhibit a visible darkening, or they may receive a latent image, and this latent image may have a capacity of being rendered visible either by receiving a deposit of metallic silver or by decomposition by alkalies in connection with reducing agents. These two last mentioned phenomena are very distinct in their character, for in the first of them the image is produced entirely by the addition of silver not previously present. In the second, no silver whatever is added, but that portion of substance which received the direct action of light, undergoes decomposition by subsequent treatment. In both cases the action of light sets up a molecular change. The portions acted upon by light become, in the one case, more apt to attract a precipitate in the act of formation (for example, silver precipitated by ferrous sulphate); in the other case they are more readily attacked by certain reducing agents.

The silver compounds which exhibit the greatest tendency to form latent images by the action of light are of course the iodide, bromide, and chloride. But the same tendency is shared to a less degree by other compounds, and the latent image formed upon them may belong to either of the above mentioned classes. The capacity of a certain number of silver salts to receive latent images, developable by a precipitate in the act of formation, was examined many years ago by Mr. Robert Hunt. Since then the matter has received but little attention, and if I am not mistaken, no investigations have at any time been made as to the capacity of silver salts other than iodide, bromide, and chloride to receive latent images of the second sort, viz: those susceptible of alkaline development, in the entire absence of silver nitrate. This subject I have recently examined with the following results:

Soluble salts of acids capable of forming insoluble or nearly insoluble salts with silver were selected and the surface of very pure paper was impregnated with them. After drying, the papers were floated on a solution of silver nitrate, containing about twenty grams to the ounce, acidulated with half a drop of nitric acid, sp. gr. 1·28 to the ounce of solution. The excess of silver nitrate was then washed out. One set of papers were then simply dried, another set were soaked for about a minute in a ten grain solution of gallo-tannic acid, and then again washed.

The salts thus formed on the surface of the paper were exposed to a strong diffuse light for, in some cases, twelve seconds, in others, seven. They were then submitted to the action of a very weak solution of pyrogallol, ammonium carbonate and potassium bromide, the latter used to check the rapidity of the action of the other agents.

Silver citrate and *tartrate* both gave rather weak images. The citrate showed a strong tendency to irregular reduction. Nothing of this appeared in the case of the tartrate.

Silver platinocyanide gave quite a strong image, stronger than any other substance tried, except of course the silver bromide used for comparison.

Silver mucate gave a very faint image with much irregular reduction.

Silver pyrophosphate behaved in the same way.

Silver arsenite gave a moderately strong image, coming next to the platinocyanide, and like it, clear and free from all irregular reduction.

Silver sulphocyanide, an extremely faint image with much irregular reduction.

Silver antimonio-tartrate, a weak image entirely free from irregular action.

Silver fulminurate, weaker than the last mentioned, but also clear.

Silver nitrite, similar to the last.

Silver hippurate, an excessively faint image with much irregular reduction.

The following substances showed (with the above mentioned exposures) no trace of a latent image:

Silver salicylate,
" *valerate*,
" *succinate*,
" *sulphite*,
" *resinate*,
" *phosphate*,
" *metaphosphate*,
Silver tungstate,
" *ferrocyanide*,
" *nitroprusside*,
" *chromate*,
" *carbonate*,
" *oxalate.*

As these experiments were strictly limited to the subject under investigation, viz: production of latent images capable of development by the action of pryrogallol and ammonia it must be understood that the insensitiveness spoken of is *insensitiveness to this particular action* with a rather brief exposure, and under the conditions mentioned. And this action is that to which the iodide, bromide, and chloride, exhibit their highest degree of sensitiveness, rendered evident by an exposure very much shorter than that given in these investigations.

As respects the action of tannin, which action was separately investigated with respect to every one of the above salts, it appeared that no substance, insensitive in the absence of tannin, acquired sensitiveness by its presence. It was also doubtful if in any case tannin increased the sensitiveness of any of these substances, a fact which, in view of the increased sensitiveness conferred by tannin on the silver haloids, is remarkable.

Philadelphia, March 22, 1877.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Chemical Actions of the Silent Electric Discharge.*—Berthelot has published in full his memoir on the various chemical actions which he has observed to be produced by the silent electric discharge (*effluve electrique*). The first part treats of the absorption of nitrogen by organic substances under these conditions, and has already been noticed in these pages. The second part treats of the same absorption under the influence of atmospheric electricity, the experiments being made at the Meteorological Observatory of Montsouris, one armature of the apparatus being put in contact with the earth and the other with a layer of air two meters above it, the difference of potential being measured by means of a Thomson–Branly electrometer. Twelve tubes were employed, in five of which moistened filter paper was placed, in the

second five moistened dextrin, while the last two contained internal armatures of silver and were filled with oxygen in order to detect the formation of ozone. Two of each of the five tubes were filled with pure nitrogen, two of each with ordinary air, while the remaining one of each sort was left open to the air. The experiments continued from July 29 to October 5, 1876, the mean electric tension being that of 3·5 Daniell cells, though it varied from + 60 to − 180 during the two months. In the ten tubes containing nitrogen or air, the nitrogen was fixed by the organic substance forming an amide which soda-lime decomposed at 300° to 400°, yielding ammonia. The third part considers the importance, in view of the facts above described, of studying in a connected and methodical manner the electric state of the atmosphere, since the fixation of nitrogen in this way must play an important part in the fertilization of the soil, in the theory of fallowing, and in the development of plants and agricultural products. In the fourth part, Berthelot considers the absorption of free hydrogen by organic matters under the same circumstances. Benzene absorbed 250 times its volume of hydrogen, yielding a polymer of C_6H_8. Turpentine oil and acetylene acted similarly; the latter yielding a solid polymer which on heating yielded ethylene, crotonylene, and ethyl hydride. The fifth part treats of the formation and decomposition of binary compounds by the silent discharge. A mixture of one volume nitrogen and three volumes hydrogen yields three per cent of ammonia, while ammonia is decomposed yielding three per cent of its constituent gases. Sulphurous oxide yields ten per cent of free oxygen and insoluble sulphur. Carbonous oxide yields Brodie's hypocarbonous oxide C_4O_3. In the sixth part the various forms of apparatus used by the author in these researches, are described.—*Ann. Chim. Phys.*, V, x, 51, Jan. 1877. G. F. B.

2. *Is Nitrogen oxidized by Ozone in presence of Alkalies?*—The statement made by Schönbein in 1849, that ozone united with free nitrogen in presence of alkalies to form nitrous compounds, is generally accepted, as furnishing an important basis for the received theories of nitrification. BERTHELOT has examined the question anew, taking care to avoid the causes of error existing in Schönbein's experiments, two in number; first the use of lime water, which generally contains nitrates; and second the use of unwashed ozone from the phosphorus, which contains nitrous compounds produced in the slow oxidation of the metalloid. Oxygen collected over boiled water was ozonized by the silent discharge, and four liter flasks were three-fourths filled with it, the other fourth being filled with air. Ten c. c. baryta water were placed in each and allowed to remain over night. Although the ozonized oxygen contained twenty-three milligrams of ozone in a liter, not a hundredth of a milligram of nitrate was formed in the four flasks. Air ozonized by phosphorus and allowed to stand twenty-four hours, and which contained 5·7 milligrams ozone per liter, gave less than a twentieth of a milligram of nitrate; essentially the same result. The author concludes therefore that ozone does not

oxidize nitrogen under these circumstances.—*Bull. Soc. Ch.*, II. xxvii, 160, Feb. 1877. G. F. B.

3. *On the Equivalence of Nitrogen.*—VICTOR MEYER has replied to the paper of Ladenburg and Struve, noticed in the April number of this Journal, and states that he has carefully repeated their experiments, but with an entirely different result. So far as the question of the decomposition of triethylbenzylammonium iodide and the non-decomposition of benzyltriethylammonium iodide on evaporating their solutions, is concerned, Meyer finds that neither body yields a trace of benzyl iodide on evaporation; and hence that the "prägnante Unterschied" between these bodies, upon which the assertion of the non-equivalence of the bonds of nitrogen rests, has no existence. The author supposes that the salt used by Ladenburg and Struve contained some dibenzyldiethylammonium iodide, a body which gives benzyl iodide on distillation.—*Ber. Berl. Chem. Ges.*, x, 309, March, 1877. G. F. B.

4. *A new metallic element, Neptunium.*—HERMANN has made an exhaustive research on the metals of the tantalum group, in which he not only claims to have established the existence of his element ilmenium, but also the discovery of another metal, belonging to this group, which he calls *Neptunium*. The mineral worked on was labelled tantalite from Haddam, Connecticut; but proved on examination to be columbite and ferroilmenite in equal parts. The metallic oxides separated from the mineral consisted of Ta_2O_5 32·39, Cb_4O_7 36·79, Il_4O_7 24·52, Np_4O_7 6·30. To obtain the neptunium, the pulverized mineral was fused with hydro-potassium sulphate, the acid hydrates digested with ammonium sulphide and hydrochloric acid, washed well with water, dissolved in hydrofluoric acid, mixed with an equivalent quantity of potassium fluoride, and the solution diluted to forty parts boiling water to one of fluoride. On cooling, tantalum-potassium fluoride crystallized in delicate prisms. On evaporation, columbium-potassium fluoride and ilmenium-potassium fluoride crystallized out, leaving an acid mother-liquid. This was diluted with twenty parts water, heated to boiling and sodium hydrate added in excess. An amorphous precipitate of sodium neptunate was formed, mixed with minute crystals of columbate. The precipitate was collected on a filter, pressed out, and boiled with twenty-five parts of water. The columbate dissolved, the neptunate remained. The latter was fused with hydro-potassium sulphate, the fusion was treated with boiling water and the undissolved residue of neptunic acid washed and dried over sulphuric acid. Neptunic acid resembles in general the other acids of the group, but is distinguished from columbic and ilmenic acids by the insolubility of the sodium double fluoride and from tantalic acid by the ready solubility of its potassium double fluoride. Neptunic acid gives with phosphorus salt in the inner blow-pipe flame a wine-yellow bead, the sodium salt a gold-yellow glass, while tantalic acid gives no color, columbic acid gives blue and ilmenic acid gives brown. With tincture of galls, the sodium salts give, on addition of hydrochloric acid a sulphur-yellow precipitate with tantalic, orange with columbic,

brick-red with ilmenic, and cinnamon-brown with neptunic acid. Boiled with tin and hydrochloric acid neptunic acid gives, like columbic and ilmenic acids, a blue solution. From the pure crystallized double potassium fluoride, the atomic weight of neptunium was fixed as 118, its atomic volume as 18, and its specific gravity as 6·55. The formula of the acid is $Np_4O_7, (H_2O)_{1\cdot5}$. The sodium salt crystallizes in prisms. The author prepared metallic columbium and ilmenium in the pure form and determined the amount of oxygen taken up by these metals on heating them in the air. Columbium required 20·49 and ilmenium 37·96 of oxygen; the amount obtained by Rose being 20·60 and by Marignac 38·00. Rose, therefore, it is clear, had pure columbium; while it is equally clear, according to Hermann, that Marignac must have had nearly pure ilmenium. This is stated to be a necessary result from the method of preparation. After crystallizing out the tantalum-potassium fluoride, Marignac evaporated and re-crystallized, obtaining a nearly pure ilmenium-potassium fluoride, from which he prepared his metal. Hermann's paper concludes with an account of his methods of separating the metals of this group, and descriptions of their compounds.—*J. pr. Ch.*, II, xv, 105, Feb. 1877.

G. F. B.

5. *On the Phosphorescence of Organic Liquids.*—Radziszewski, having had his attention called to the phosphorescence of lophin when acted on by potassium hydrate and oxygen, has extended his observations to other bodies and finds that paraaldehyde, metaaldehyde, aldehyde-ammonia, furfurin, hydroanisamide, anisidine, hydrocumamide, and hydrocuminamide, have all the same property. Since these bodies are all either aldehydes or ammonia derivatives of aldehyde, their luminosity may be due to the oxidation of the aldehyde. He therefore examined formic aldehyde, and observed a bright phosphorescent light when its solution in alcohol potash was agitated, and the formation of potassium formate was proved. In the light of Duchemin's statement that *Noctiluca miliaris* produces on delicate skins an irritation like nettles, the author suggests that this animal, like ants, secretes formic acid not as such but as the aldehyde, which in the process of oxidation is the cause of their luminosity. When a current of oxygen is passed through a hot alcoholic solution of grape sugar containing potash, it becomes weakly luminous, a fact which in so far, confirms the aldehyde nature of glucose.—*Ber. Berl. Chem. Ges.*, x, 321, March, 1877. G. F. B.

6. *On Melezitose.*—In 1858, Berthelot described a new compound sugar existing in the Briançon manna prepared from the larch (*Larix Europea*). Villiers has now examined a manna collected in Lahore, produced by exudation from the *Alhagi Maurorum*, a thorny shrub belonging to the family of the Leguminosæ. It is abundant in Persia, where it is used both for medicine and as food under the name of Turanjbin. Crystallized from water and then from alcohol, it was obtained in the form of white bulky crystals, containing one molecule of crystal-water which they lose even in dry air at the ordinary temperature, and then

have the formula $C_{12}H_{22}O_{11}$. Its solution is dextrogyrate, rotating +94° 48′ referred to the neutral tint, or 88° 51′ referred to the yellow light of sodium. On ebullition with dilute sulphuric acid, the rotary power changes slowly, being reduced at the end of an hour to +53°. It does not reduce copper tests until after reduction, and yields on oxidation with nitric acid, oxalic acid only. It melts at 140°. All these points prove it to be identical with the melezitose of Berthelot. It crystallizes in clinorhombic prisms.—*Bull. Soc. Ch.*, II, xxvii, 98, Feb. 1877. G. F. B.

7. *Tri-substitution derivatives of Benzol;* by EDGAR F. SMITH, Ph.D., Assistant in Analytical Chemistry, University of Pennsylvania. (Abstract of Inaugural Dissertation at Göttingen, 1876.) —The investigation of the tri-substitution compounds of benzol has only of late engaged the attention of chemists. The following results, recently obtained by me, are presented as a contribution to the knowledge of bibromnitro-, bibromamido-, tribrom-, and bibromhydroxylbenzoic acids.

PARABROMMETABROMNITROBENZOIC ACID.

$C_6H_2Br^pBr^mNO_2COOH$. Fusing point 162° C.

This acid was obtained by nitriring parabrommetabrombenzoic acid discovered by Hübner and Burghard (Burghard's Dissertation, Göttingen, 1875). The fusing point of this latter acid is 227°–230° C. To effect the introduction of the nitro-group (NO_2), the acid obtained by the above chemists was heated upon a water-bath with fuming nitric acid. The application of a more intense heat produces entirely different acids. In the cold, fuming nitric acid was without action upon the bi-brom acid.

After the conversion of the bibrom acid into the corresponding nitro-acid by means of fuming nitric acid, aided by gentle heat, the whole is allowed to cool and water then added to the solution. The bi-bromnitro acid was partially precipitated in flocculent masses; the greater quantity of the acid, however, remained dissolved. All of it was obtained by evaporating the solution, placed in a porcelain dish, to dryness upon a water bath, and the residue purified by boiling it with sodium carbonate.

In hot water the acid is easily soluble, crystallizing from it in fine colorless needles. The fusing point was found to be 162° C. The acid is not volatilized by steam. When heated between watch glasses it sublimes with partial decomposition. It is very probable this acid is identical with that obtained by Hübner and Angertein (Angertien's dissertation, Göttingen, 1869). The relation of the nitro-radical to the COOH-group or to the bromine atoms has not yet been determined.

Parabrommetabromnitrobenzoate of Lead: $(C_6H_2Br^pBr^mNO_2 COO_2)_2Pb$. Obtained by precipitating a hot solution of the potassium salt with lead acetate. A white insoluble powder.

Lead estimation, 0·2755 grm. dry salt gave 0·0965 grm. $PbSO_4$ =0·0659 grm. Pb = 23·95 per cent. Theoretical percentage = 24·21 per cent Pb.

Carbon and hydrogen determination: 0·2143 grm. salt gave 0·0433 grm. carbon = 20·1 per cent. Farther, 0·0256 grm. H_2O = 1 per cent H.

Nitrogen determination: 0·1581 grm. salt = 3·53 per cent N.

Theoretical percentages = Carbon, 19·7 per cent, hydrogen 0·50 per cent, nitrogen = 3·26 per cent.

Parabrommetabromnitrobenzoate of Sodium: $C_6H_2Br^pBr^mNO_2COONa+3H_2O$. This salt crystallizes from dilute solutions in needles, often forming bundles. From concentrated solutions it is obtained in almost colorless, broad shining leaflets. Soluble in cold and hot water. The anhydrous salt requires 6·63 per cent Na. Found 6·66 per cent Na.

Parabrommetabromnitrobenzoate of Potassium: $C_6H_2Br^pBr^mNO_2COOK$. The pure acid was boiled with potassium carbonate, the salt crystallizing from the solution in needles. Very soluble in warm water.

Anhydrous salt requires 10·76 per cent K; found 10·61 per cent K.

Parabrommetabromnitrobenzoate of Barium: $(C_6H_2Br^pBr^mN_2OCOO)_2Ba+H_2O$. Broad colorless, shining needles, easily soluble in water. Anhydrous salt requires 17·45 per cent Ba; found 17·34 per cent.

Parabrommetabromnitrobenzoate of Calcium: $(C_6H_2Br^pBr^mNO_2COO)_2Ca+3\frac{1}{2}H_2O$. Obtained by boiling the free acid with either calcium hydrate or carbonate. Exceedingly difficult to obtain pure. Occurs in red-colored needles, almost insoluble in water. The analysis of the anhydrous salt gave 5·52 per cent Ca; required 5·81 per cent Ca.

Parabrommetabromnitrobenzoate of Magnesium: $(C_6H_2Br^pBr^mNO_2COO)_2Mg$. Crystallizes in needles forming star-shaped groups. Difficultly soluble in water. Analysis gave 3·25 per cent Mg; required 3·59 per cent.

PARABROMMETABROMAMIDOBENZOIC ACID.

$C_6H_2Br^pBr^mNH_2COOH$. **Fusing point 225° C.**

Very easily obtained from the preceding acid by heating it with hydrochloric acid and a calculated amount of tin. The amiding takes place without any violent action. The acid only unites with bases, not with acids. Soluble in a large quantity of water; readily soluble in a mixture of equal parts alcohol and water, from which it crystallizes upon cooling in beautiful flocks consisting of minute needles. The fusing point of the acid is 225° C., considerably higher than that of a similar acid obtained by Angertein (Dissertation, Göttingen, 1869). Completely decomposed when fused. A nitrogen determination was made of the free acid. Required percentage of Nitrogen = 4·75 per cent; found 5·03 per cent N.

Parabrommetabromamidobenzoate of Barium: $(C_6H_2Br^pBr^mNH_2COO)_2Ba+4H_2O$. An aqueous solution of the sodium salt was decomposed with barium chloride, the precipitate filtered and washed. The salt forms minute shining needles, generally united to bundles. Very soluble in water. Analysis of anhydrous salt gave 18·90 per cent Ba; required 18·89 per cent.

Parabrommetabromamidobenzoate of Calcium: $(C_6H_2Br^pBr^m NH_2COO)_2Ca+4\frac{1}{2}H_2O$. Obtained by decomposing the ammonium salt with calcium chloride. The salt is tolerably insoluble in water, crystallizing from it in small reddish-brown colored needles. Analysis gave 6·37 per cent Ca; required 6·51 per cent Ca.

Parabrommetabromamidobenzoate of Strontium: $(C_6H_2Br^pBr^m NH_2COO)_2Sr+2H_2O$. Large, dark-red colored needles. Difficultly soluble in hot water. An analysis of the anhydrous salt gave 12·55 per cent Sr; required 12·93 per cent Sr.

Parabrommetabromamidobenzoate of Copper: $(C_6H_2Br^pBr^m NH_2COO)_2Cu$. From the ammonium salt by treating it with copper acetate. Bright green in color; perfectly insoluble in water. Analysis: 9·23 per cent Cu found; required 6·70 per cent Cu.

TRIBROMBENZOIC ACID.

$C_6H_2Br^pBr^mBr^?COOH$. Fusing point 195° C.

I obtained this acid by converting the preceding bibromamidobenzoic acid, by means of nitrous acid, into the corresponding diazo-compound and then boiling this last product with pure concentrated hydrobromic acid. The pure acid obtained from the barium salt after many recrystallizations, presented the constant fusing point 195° C. The acid is almost perfectly insoluble in water. Very soluble in a mixture of one part water and two parts of alcohol, recrystallizing out of this in small colorless needles. Fuses with partial decomposition.

Tribrombenzoate of Lead: $(C_6H_2Br^pBr^mBr^?COO)_2Pb$. Obtained by precipitating the ammonia salt with lead acetate. It forms a white insoluble compound. This salt was taken in estimating the carbon and hydrogen. Found 17·98 per cent carbon, and 0·89 per cent hydrogen. Calculated 18·20 per cent carbon, and 0·43 per cent hydrogen.

The bromine was determined by burning the pure acid with oxide of lime and the calcium bromide decomposed by silver nitrate. Found percentage of bromine, 66·85 per cent; calculated 66·48 per cent.

Tribrombenzoate of Barium: $(C_6H_2Br^p Br^m Br^? COO)_2Ba+5H_2O$. Formed when the free acid is boiled with barium carbonate. The pure salt forms needles easily soluble in water. The anhydrous salt when analyzed gave 15·53 per cent Ba; calculated 16·06 per cent Ba.

PARABROMMETABROMOXYBENZOIC ACID.

$C_6H_2Br^pBr^mOH^?COOH$. Fusing point 218° C.

An etherial solution of parabrommetabromamidobenzoic acid was treated with nitrogen trioxide until the corresponding diazo-compound formed, and being insoluble in ether fell out in flocculent masses. The diazo-compound, perfectly dry, was boiled with pure water—the OH group being thereby introduced. This acid is difficultly soluble in water. The fusing point is 218°. It crystallizes in colorless needles. When fused, partial decomposition occurs. A beautiful violet color is imparted to its solution, when treated with a few drops of ferric chloride. A combustion of the acid gave 29·00 per cent carbon and 1·28 per cent hydrogen; calculated 28·38 per cent carbon and 1·35 per cent hydrogen.

Parabrommetabromoxybenzoate of Sodium: $(C_6H_2Br^pBr^mOH^? COONa)+H_2O$. Obtained by boiling the barium salt with sodium carbonate. The salt is exceedingly soluble in water, forming light yellow colored needles, frequently united to bundles. An analysis of the anhydrous salt afforded 7·45 per cent Na; required 7·23 per cent Na.

Parabrommetabromoxybenzoate of Barium: $(C_6H_2Br^pBr^mOH^? COO)_2Ba$. When an aqueous solution of the acid is boiled with barium carbonate, this salt is formed. It crystallizes in red warty masses. It is rather insoluble in water. I obtained by analysis 18·80 per cent Ba; required 18·84 per cent Ba. E. F. S.

Philadelphia, Pa.

8. *Kinetic Theory of Gases.*—M. BOLTZMANN, in a communication to the Vienna Academy on the nature of gas molecules, abandons the notion that they behave like aggregates of material points (the atoms). He considers that in estimating the impact action of the molecules we may almost regard the whole aggregate which we denote as an individual gas molecule, and which may consist of different substances, perhaps even ether atoms, as rigid. It is found that then the ratio of the heat-capacities of the gas must be $1\frac{2}{3}$, when the gas-molecules have a ball-form. The ratio of the heat-capacities will be 1·4 if the molecules have the form of rigid bodies of rotation, but which are not balls; and $1\frac{1}{3}$ if they are of any other form of rigid bodies. These numbers at least seem to agree so far with those found experimentally, that one cannot say that experiment furnishes a contradiction of the theory thus modified. It is further shown that the values experimentally got for the heat-capacity, under this view, are in satisfactory agreement with the heat-capacities of solid bodies. Of course the gas molecules cannot be absolutely rigid bodies; this is already disproved by spectral analysis, but it may be that the vibrations producing gas spectra are merely brief shiverings during the shock of two molecules, comparable to the sound perceived on the shock of two ivory balls.—*Nature*, xv, 306.

E. C. P.

9. *Vowel "Clang."*—M. AUERBACH, from researches on the nature of the vowel "clang," in Prof. Helmholtz's physical laboratory, comes to the following conclusions, which appear to throw new light on some unsolved problems:—1. All clang, especially the vowels of the human voice and speech, are to be defined as the consequence of the joint action of two moments, a relative and an absolute. 2. The relative moment is the mode of distribution of the whole intensity among the individual partial tones as deter-

mined by their ordinal number. The absolute is the dependence of the whole intensity of the absolute pitch of the partial tones, and the modification of the distribution, are clangs of the fundamental tone therewith connected. 3. The difference of the vowels in the former relation is a result of the power of changing the form of the mouth cavity. The differences of the absolute pitches characterizing the various vowels, and of their influence, are a result of the power of changing the volume and size of the mouth cavity. 4. The first partial tone is always the strongest in clang; it deserves, therefore, the name of fundamental tone. 5. The intensity of the partial tones as such, decreases in general as their ordinal number increases; exceptions indicate the nearness of the boundary of the consonant region. 6. The intensity of the partial tones decreases more slowly the nearer the vowel clang is, therefore more quickly the duller this is. 7. The characteristic pitch is higher the clearer, and deeper the duller, the vowel clang. 8. The variations of the intensity, in consequence of the influence of the characteristic pitch, are greater the fuller the vowel is. Very slight variations indicate the nearness of the consonant region. 9. All the vowels admit of being sung within the whole range of the human voice; but the dull speak in very high, the clear in very deep, positions. 10. A little attention only is needed to perceive in a vowel clang the over-tones (often comparatively very strong), without artificial aids. They then sound very similar to the pure tuning-fork tones.—*Pogg. Ann. Erg.*, viii, II, 177; *Nature*, xv, 441. E. C. P.

10. *Ultra Red Spectrum.*—M. E. Becquerel has studied the invisible red rays of the spectrum by the aid of phosphorescence. The light is admitted into a darkened room through two slits, so that one beam shall fall on a bisulphide of carbon prism, and form the spectrum which is to be examined. The second beam passes through a prism of flint glass which is so turned that the ultra violet portion of its spectrum shall fall on the ultra red portion of the other spectrum. The flint glass spectrum is not focussed on the screen, or the slit is opened wide, so that the ultra violet lines and bands shall not be visible. These spectra are received on a plane surface covered with some phosphorescent substance. The phosphorescent hexagonal blende is best suited to this purpose, as it is strongly luminous, though it loses this effect more rapidly than the sulphides of the alcaline earths, but less rapidly than carbonate of lime. Bands are then observed beyond A for a distance somewhat greater than that from A to D. Two bands are found near A which M. Becquerel has called A_1 and A_2; then follow a group of four bands or lines A', A'_1, A'_2, A'_3, of which the first three are nearly equidistant. The wave length of A' is 840, that of A being taken as 761·5. Beyond is a broad diffuse band A'' and near the limit of vision is A''' a large band with well marked borders, especially on its more refrangible side. The wave lengths of its two edges are 1220 and 1310. Since the light of a diffraction spectrum was too small, the wave-lengths were

determined by interposing an apparatus giving colored rings by means of thin layers of air. Attempts have been made, as yet without success, to form a phosphorescent eye-piece like the fluorescent eye-piece of Mr. Soret.—*Bib. Univ.*, ccxxviii, 306.

E. C. P.

11. *Fluorescence.*—M. LOMMEL, continuing his researches on fluorescence, arrives at the following conclusions:—1. There are two kinds of fluorescence. In one, each homogeneous ray falling within the limits of the fluorescence-spectrum excites not only rays of greater and equal, but also waves of shorter wave-length; the latter, so far as they belong to the region in question. In the second kind each homogeneous ray excites only rays of greater or equal wave-length. 2. There are substances which have only the first kind of fluorescence; each excitant ray excites the whole fluorescence spectrum. Hence they are not subject to Stokes's law. Such are napthalin, red chlorophyll and eosin. 3. There are substances which have only the second kind of fluorescence, and which therefore throughout their fluorescence spectrum, obey Stokes's law. Such are most of the fluorescent substances hitherto examined. 4. There are substances which have both kinds of fluorescence, so that the first kind is proper to a certain portion of their fluorescence spectrum, and the second kind proper to their remaining parts. Hence these obey Stokes's law only in part. Such are chamdelin red, blue and green.—*Pogg. Ann.*, clix, 514; *Nature*, xv, 441. E. C. P.

12. *On the Equilibrium of heterogeneous substances;* by J. WILLARD GIBBS, of Yale College. 141 pp. 8vo.—The paper on this subject by Professor Gibbs, published in volume iii. of the Transactions of the Connecticut Academy of Sciences (1876), received the following exposition by Professor J. Clerk-Maxwell, of Cambridge, England, in his lecture on the occasion of the recent Loan Exhibition:

"The thermodynamical problem of the equilibrium of heterogeneous substances was attacked by Kirchhoff in 1855, when the science was yet in its infancy, and his method has been lately followed by C. Neumann. But the methods introduced by Professor J. Willard Gibbs, of Yale College, Connecticut, seem to me to be more likely than any others to enable us, without any lengthy calculations, to comprehend the relations between the different physical and chemical states of bodies, and it is to these that I now wish to direct your attention.

In studying the properties of a homogeneous mass of fluid, consisting of n component substances, Professor Gibbs takes as his principal function the energy of the fluid, as depending on its volume and entropy together with the masses, $m_1, m_2 \ldots . m_n$, of its n components, these $n+2$ variables being regarded as independent. Each of these variables is such that its value for any material system is the sum of its values for the different parts of the system.

By differentiating the energy with respect to each of these variables we obtain $n+2$ other quantities, each of which has a physical significance which is related to that of the variable to which it corresponds.

Thus, by differentiating with respect to the volume, we obtain the pressure of the fluid with its sign reversed; by differentiating with respect to the entropy, we obtain the temperature on the thermodynamic scale; and by differentiating with respect to the mass of any one of the component substances, we obtain what Professor Gibbs calls the potential of that substance in the mass considered.

As this conception of the potential of a substance in a given homogeneous mass is a new one, and likely to become very important in the theory of chemistry, I shall give Professor Gibbs's definition of it.

'If to any homogeneous mass we suppose an infinitesimal quantity of any substance added, the mass remaining homogeneous and its entropy and volume remaining unchanged, the increase of the energy of the mass, divided by the mass of the substance added, is the potential of that substance in the mass considered.'

These $n+2$ new quantities, the pressure, the temperature, and the n potentials of the component substances, form a class differing in kind from the first set of variables. They are not quantities capable of combination by addition, but denote the intensity of certain physical properties of the substance. Thus the pressure is the intensity of the tendency of the body to expand, the temperature is the intensity of its tendency to part with heat; and the potential of any component substance is the intensity with which it tends to expel that substance from its mass.

We may therefore distinguish these two classes of variables by calling the volume, the entropy, and the component masses the *magnitudes*, and the pressures, the temperature, and the potentials the *intensities* of the system.

The problem before us may be stated thus:—Given a homogeneous mass in a certain phase, will it remain in that phase, or will the whole or part of it pass into some other phase?

The criterion of equilibrium may be expressed thus in Professor Gibbs's words—'For the equilibrium of any isolated system it is necessary and sufficient that in all possible variations of the state of the system which do not alter its energy, the variation of its entropy shall either vanish or be negative.

'The condition may also be expressed by saying that for all possible variations of the state of the system which do not alter its entropy, the variation of its energy shall either vanish or be positive.'

Professor Gibbs has made a most important contribution to science by giving us a mathematical expression for the stability of any given phase A of matter with respect to any other phase B.

If this expression for the stability (which we may denote by the letter K) is positive, the phase A will not of itself pass into the phase B, but if it is negative the phase A will of itself pass into the phase B, unless prevented by passive resistances.

The stability K of any given phase A with respect to any other phase B, is expressed in the following form:

$$K = \varepsilon + v p - \eta t - m_1 \mu_1 - \text{etc.} - m_n \mu_n$$

where ε is the energy, v the volume, η the entropy, and m_1, m_2, etc., the components corresponding to the second phase B, while p is the pressure, t the temperature, and μ_1, μ_2, etc., the potentials corresponding to the given phase A. The intensities therefore are those belonging to the given phase A, while the magnitudes are those corresponding to the other phase B.

We may interpret this expression for the stability by saying that it is measured by the excess of the energy in the phase B, above what it would have been if the magnitudes had increased from zero to the values corresponding to the phase B, while the values of the intensities were those belonging to the phase A.

If the phase B is in all respects except that of absolute quantity of matter the same as the phase A, K is zero; but when the phase B differs from the phase A, a portion of the matter in the phase A will tend to pass into the phase B if K is negative, but not if it is zero or positive.

If the given phase A of the mass is such that the value of K is positive or zero with respect to every other phase B, then the phase A is absolutely stable, and will not of itself pass into any other phase.

If, however, K is positive with respect to all phases which differ from the phase A only by infinitesimal variations of the magnitudes, while for a certain other phase, B, in which the magnitudes differ by finite quantities from those of the phase A, K is negative, then the question whether the mass will pass from the phase A to the phase B will depend on whether it can do so without any transportation of matter through a finite distance, or, in other words, on whether matter in the phase B is or is not in contact with the mass.

In this case the phase A is stable in itself, but is liable to have its stability destroyed by contact with the smallest portion of matter in certain other phases.

Finally, if K can be made negative by any infinitesimal variations of the magnitudes of the system A, the mass will be in unstable equilibrium, and will of itself pass into some other phase.

As no such unstable phase can continue in any finite mass for any finite time, it can never become the subject of experiment; but it is of great importance in the theory of chemistry to know how these unstable phases are related to those which are relatively or absolutely stable.

The absolutely stable phases are divided from the relatively stable phases by a series of pairs of coexistent phases, for which the intensities p, t, μ, etc., are equal and K is zero. Thus water and steam at the same temperature and pressure are coexistent phases.

As one of the two coexistent phases is made to vary in a continuous manner, the other may approach it and ultimately coincide with it. The phase in which this coincidence takes place is called the Critical Phase.

The region of absolutely unstable phases is in contact with that of absolutely stable phases at the critical point. Hence, though it may be possible by preventing the body from coming in contact with certain substances to bring it into a phase far beyond the limits of absolute stability, this process cannot be indefinitely continued, for before the substance can enter a new region of stability it must pass out of the region of relative stability into one of absolute instability, when it will at once break up into a system of stable phases.

Thus in water for any given pressure there is a corresponding temperature at which it is in equilibrium with its vapor, and beyond which it cannot be raised when in contact with any gas. But if, as in the experiment of Dufour, a drop of water is carefully freed from air and entirely surrounded by liquid which has a high boiling point, it may remain in the liquid state at a temperature far above the boiling point corresponding to the pressure, though if it comes in contact with the smallest portion of any gas it instantly explodes.

But it is certain that if the temperature were raised high enough the water would enter a phase of absolutely unstable equilibrium, and that it would then explode without requiring the contact of any other substance.

Water may also be cooled below the temperature at which it generally freezes, and if the water is surrounded by another liquid of the same density the pressure may also be reduced below that of the vapor of water at that temperature. If the water when in this phase is brought in contact with ice it will freeze, but if brought in contact with a gas it will evaporate.

Professor Guthrie has recently discovered a very remarkable case of equilibrium of a liquid which may be solidified in three different ways by contact with three different substances. This is a solution of chloride of calcium in water containing 37 per cent of the salt. This solution is capable of solidification at $-37°$ C., when it forms the solid cryohydrate having the same composition as itself. But it may be cooled somewhat below this temperature, and then if it is touched with a bit of ice it throws up ice, if it is touched with the anhydrous salt it throws down anhydrous salt, and if it is touched with the cryohydrate it solidifies into cryohydrate."

II. GEOLOGY AND MINERALOGY.

1. *The Lœss of the Rhine and Danube*, by THOMAS BELT, F.G.S.—Mr. Belt discusses the characters, position and height of the lœss, and the evidences in the transported bowlders, stones and organic remains it contains in some places, of its having originated in connection with the Glacial era, observing that "no

more Arctic fauna is known in the basin of the Danube and the Rhine than that of the lœss;" also that "along the northern flanks of the Carpatheans, the Scandinavian drift rises to heights of 1,000 to 1,200 feet." He adopts Lyell's view, that the valley had been excavated before the deposition took place. Instead of holding that the supply of water from the melting ice was sufficient to account for the height of the stream, he assumes, as in his former papers, that the ice accumulating along the coast and thus blocking up the drainage of the continents, dammed up the streams about their mouths and so caused lakes. He says, "I was first led to believe that the ice had effected this [result] in studying the glaciation of North America, and in 1866 I advanced the opinion that the drainage of the St. Lawrence had been blocked up by the ice moving down from the north; and that thus a great inland fresh-water sea had been formed over which icebergs floated. He says further that during a visit to North America in 1874, I found many more proofs that the drainage of the northeastern part of the continent was blocked by ice that flowed down the bed of the Atlantic from the direction of Greenland;" and from these and other facts, came the conclusion that "the drainage of Europe had been blocked up—not by Scandinavian ice, but by that which occupied the bed of the Atlantic and had reached to our western shores." Thus "the waters were raised over which floated icebergs from the north carrying the Scandinavian drift, and into this great lake the Danube and the Rhine, or the upper portions of them above its level, brought down fine mud from the glacier-capped Alps which was deposited as lœss."

There is no such damming, as far as is known, about Greenland, the subglacial streams being large and flowing freely to the sea; and hence the practicability of damming the fresh waters in the way supposed may be doubted. The assumed amount of Atlantic ice appears to be far beyond what could have existed. The article does not give the facts as to uniformity of level in the lœss along the whole course of the Rhine needed to prove that the deposits are of lacustrine origin. The facts about southern New England show that there has been no such damming by shore ice as Mr. Belt suggests; for they prove that the height of the terraces along the river-valleys has depended almost wholly on river-floods, with only such lakes as come from damming by ice or otherwise along their course. And it seems altogether probable that the height of the lœss on the Rhine and Danube had the same origin. The change of level proved for southern New England does not exceed fifteen feet; and none was needed to produce the occurring heights of the river-valley terraces. J. D. D.

2. *Thickness of the Palæozoic rocks of Central Pennsylvania.*—Mr. C. A. Ashburner, of the Geological Survey of Pennsylvania, has carefully measured a section of the rocks from the top of the Alleghany River Coal Series down to the Trenton limestone. The details are contained in his Report. The aggregate results are as follows: the Carboniferous from the top of the Mahoning

sandstone in the Coal Measures, to what is called the Upper Catskill or Pocono group (Rogers's Vespertine, No. 10) inclusive, at least 3,777 feet; Devonian strata, 7,975 feet; Oriskany sandstone (which is referred by some to the Devonian and others to the Upper Silurian) 58 feet; Upper Silurian 4,214 feet; Hudson River and Utica shale and Trenton at least 2,370 feet—making in all 18,394 feet.

In the section, the Pocono sandstone has a thickness of 2,133 feet, and is overlaid by the Mauch Chunk Red Shale (Rogers's Umbral), 1,100 feet; the Pottsville conglomerate (Millstone grit, Rogers's Seral), 280 feet; and the Alleghany River (or Lower Productive) Coal Measures, 264 feet. The Devonian commences with the Catskill Red sandstone (Rogers's Ponent), 2,680 feet thick, and is underlaid by 90 feet of "transition strata" between it and the next below; 1,860 feet of Chemung shales (Vergent); 1,450 feet Portage flags (Vergent); 325 feet Genesee slate (Upper Cadent); 635 feet Hamilton shales (Cadent); 875 feet Marcellus Black shale (Lower Cadent); 60 feet Upper Helderberg limestone (Post-meridian); 58 feet Oriskany sandstone (Meridian). The Upper Silurian includes 742 of Lower Helderberg beds (the upper 162 feet limestone); 440 feet of Onondaga marlytes; 1,960 feet of Clinton shales and ore-rocks (the ore-rocks 53 feet thick and including two beds of ore 12 inches apart, the upper of 10 inches average thickness and the lower of 14 inches); 1,330 feet of Medina sandstone; 568 of Oneida sandstone (Levant). The Lower Silurian includes Hudson River shale 800 feet; Utica shale 1,070 feet; Trenton limestone 500 feet. Below lie the Calciferous and Potsdam, of unknown thickness.

3. *Notes upon the Lower Helderberg rocks of Port Jervis, N. Y.*;[*] by Dr. S. T. Barrett.—The subdivisions and fossil contents of the Lower Helderberg and underlying rocks near this village are sufficiently peculiar to warrant their description. They are situated in the midst of what has very appropriately been called the Appalachian System; a system of long monoclinal ridges fronting the Atlantic and sloping backward with varying dips toward the northwest. These monoclinal ridges trending northeast and southwest are crossed more or less obliquely by a secondary and compensatory system of flexures trending nearly north and south. The Lower and Upper Helderberg strata together constitute, when elevated above the drift, a low monoclinal ridge extending parallel with the Shawangunk (pronounced Shongum) Mountain, at a distance varying from less than a mile to three or four miles northwest of the crest-line of that mountain. The transverse or secondary system of flexures cause the Helderberg Ridge to rise and sink in a succession of anticlinal and synclinal folds, which add very much to the picturesqueness of the long monoclinal valley in which Port Jervis is situated. The roads across this ridge are made necessarily in the synclinals,

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[*] Abridged by the author from a paper upon the same subject in vol. xi, Ann. Lyc. Nat. History, N. Y.

and the lime-quarries are worked in the southeastern fronts of the anticlinals. This arrangement is further deversified by the dip; the ridges and valleys being narrowest where that is steepest, and broadest where it is most nearly horizontal. These secondary flexures are very near together here, three of them occurring in the space of six miles lineally of the ridge. Bennet's Quarry is the central one of these, and has been most studied by the writer. Nearpass' and Buckley's Quarries lie south and north of it respectively. The strata visible at any quarry depends upon the extent of the upheaval, the amount of talus at bottom, and of erosion at the top.

There are at Bennet's Quarry, beginning at the bottom:

No. 1. Tentaculite Limestone, Prof. Cook's Quarry Stone;* makes the best of lime for building purposes; about twenty feet thick.†
No. 2. Favosite Limestone; from two to five feet thick.
No. 3. Lower Pentamerus and Cherty Limestone; together, forty feet thick.
No. 4. Delthyris Shale; one hundred and twenty feet thick.
No. 5. Upper Quarry Stone; ten feet thick.
No. 6. Upper Shale; one hundred and fifty feet thick.
No. 7. Trilobite Layers; five to ten feet thick.
Nos. 5, 6 and 7 are believed to belong to the Upper Pentamerus subdivision; and are succeeded by rocks of the Oriskany Sandstone and Cauda Galli Grit formations, the latter exhibiting a thickness of from five hundred to eight hundred feet.

The following fossils were very kindly identified for me by Prof. Hall:

From No. 1, Tentaculate Limestone; *Tentaculites gyracanthus*, *Spirifer Vanuxemi*, *Megambonia ovoidea*, and *Strophodonta varistriata.*

From No. 2, or Favosite Limestone, *Favosites Helderbergi*, a *Cyathophyllum*, and *Pentamerus galeatus.*

From No. 3, or Lower Pentamerus and Cherty Limestones; *Dalmanites pleuroptyx*, *Pentamerus galeatus*, and a form of *Lichenalia.*

From No. 4, Delthyris Shale; *Spirifer macropleurus*, *S. lamellosus*, and many more forms peculiar to and usually abundant in this subdivision.

From No. 5, Upper Quarry Stone; *Rhynchonella ventricosa* and *Platyceras retrorsum.*

From No. 6, Upper Shale. This subdivision is very sparingly fossiliferous.

From No. 7, Trilobite layers; *Chonetes complanata*, *Rensselaeria mutabilis*, *Homalonotus Vanuxemi*, *Dalmanites pleuroptyx*, *D. nasuta*, *D. micrurus*,‡ *D. dentata*, *Hyolithes centennialis*, *Strophomena rhomboidalis*, *S. Conradi*, *Strophodonta cavumbona*, *S. planulata*, *S. Beckii*, *S. Leavenworthana*, *S. varistriata*,

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* Geology of New Jersey, p. 159.

† The thickness of strata as given in this paper, and the names of subdivisions are different from the original paper. I think the thickness was overestimated in my first.

‡ Described by myself in this Journal, vol. xi, p. 200. Described by me in Ann. Lyc. Nat. Hist. N. Y., vol. xi.

Orthis subcarinata, *O. multistriata*, *Spirifer arrectus*, *Cyrtia rosstrata*, *Pterinea textilis*, *Discina discus*, *D. Conradi*, *Holopea antiqua*, *Loxonema Fitchiana*, *Tentaculites elongatus*, a form allied to *Trematis*, a *Beyrichia*, probably *B. granulifera*, and some other species not determined.

I have been thus exhaustive in the enumeration of the species contained in this subdivision, because the richness of its fauna, separated as it is by more than a hundred feet of nearly unfossiliferous strata from the true Delthyris Shale below, and the number of species apparently unknown elsewhere, make it one of the anomalies in the geology of the locality. The most abundant fossils, and in the order named, are *Chonetes complanata*, *Rensselaeria mutabilis*, and *Dalmanites dentata*. The stony casts of these fossils literally make up the rock.

The Favosite Limestone,* No. 2, is also peculiar. It is so full of large corals, principally Favosites, that it is at first hard to believe it is not the equivalent of the Coralline of Schoharie, described by Prof. Hall in his Palæozoic Fossils of New York, volume ii. It occupies, however, about the position assigned by that distinguished paleontologist to the Stromatopora limestone. It is a coarse, brecciated limestone, and contains, besides Favosites, an abundance of encrinal fragments in an unrecognizable condition, *Chætetes Helderbergia*, *Pentamerus galeatus*, *Strophodonta punctulifera*, and other Delthyris Shale fossils. *Favosites Helderbergia* is certainly present, but unless that species is very variable, it is not the only form of the genus so numerously represented in this layer. The most common type resembles very closely the *F. Niagarensis* of Hall. Although this Favosite Limestone is very distinct from the Coralline of Schoharie, the presence of *F. Niagarensis* in the former, if it is present, would seem to make that fossil of little account in determining the age of the latter limestone.

4. *Geological and Geographical Survey of the Territories*, F. V. HAYDEN, U. S. Geologist-in-charge.—The Survey has recently issued a "Drainage Map" of Colorado; the primary triangulation by J. T. GARDNER and A. D. WILSON, the topography by A. D. WILSON, G. R. BECHLER, H. GANNETT, G. B. CHITTENDEN, and S. B. LADD. Also a Hypsometric Map of the United States, by HENRY GANNETT, M.E., a map of contour lines, which includes the whole of the United States, and gives, far better than any map hitherto published, the topography of this part of the continent. Mr. Gannett, besides being an engineer himself, is the author of the Report, from this Survey, containing full lists of all heights that have been determined in the country, and he was thus prepared for making this diagram of the collected facts. Such a map is of course and always will be capable of improvement. But it brings out well the great features of the mountain region west of the Mississippi. The contour lines are those of 500 and 1,000 feet, and of each added 1,000.

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* **Name suggested by Prof. D. S. Martin, of Rutgers Female College, N. Y.**

A new number of the *Bulletin of the Survey* contains a paper entitled "a Calendar of the Dakota Nation"—a document of pictorial hieroglyphics, comprising the chief events in Dakota history, during the 71 years following 1799, with its interpretation, by Lieut.-Col. G. Mallery; also others—on the Kjökkenmöddings and graves of a former population of the coast of Oregon, by P. Schumacher, with 22 maps and plates; on the Twana Indians of the Skokomish Reservation in Washington Territory, by Rev. M. Eells; Notes on a Collection of Noctuid Moths, made in Colorado in 1875 by Dr. A. S. Packard, Jr., by A. R. Grote; on the Tineina of Colorado, and on new Entomostracans from Colorado, by V. T. Chambers; on a new Cave Fauna in Utah, and descriptions of new Phyllopod Crustacea from the West collected by Dr. T. Watson and Dr. E. Coues, by Dr. A. S. Packard, Jr.; Notes on some Artesian borings along the line of the Union Pacific Railroad in Wyoming Territory, by F. V. Hayden.

These Artesian borings, seven in number, are located between Rawlins and Green River, and were made by the chief engineer of the Pacific Railroad, Mr. T. E. Sickles. The surface varies in height from 6,224 to 7,100 feet—the latter on the "Continental divide." The beds passed through were Tertiary or Tertiary and Cretaceous, and lie in a basin, very nearly horizontal. No. 1 counting from the west, near Rock Springs, 1,145 feet deep, stopped at the bottom of the Fox Hill group of the Cretaceous, and afforded a flow at the surface of 960 gallons per hour, or 26 feet above it of 570 gallons per hour. No. 2, near Point of Rocks, 1,000 feet deep, stopped at the top of the Fox Hill group, and afforded an abundant supply of water at 17 feet from surface. No. 3, near Bitter Creek, 696 feet deep, descended into the Laramie group, the upper part of the Lignitic series, "and yields 2,160 gallons per hour, while flowing 1,000 gallons per hour. The most western, just east of Creston, 1,105 feet deep, reached to the bottom of the Cretaceous, and yields 2,000 gallons of water per hour; water ten feet from the surface."

5. *Note on the Criticism of Prof. Stevenson;* by A. C. Peale. (Communicated).—The only point in Prof. Stevenson's criticism of my notes on the age of the Rocky Mountains in Colorado,* which requires an answer is as follows:

On page 298 he says that on page 174 of my article "the statement is made that the Trias is present in Southwestern Colorado and Northern New Mexico," and that I use its presence there as a strong proof of its presence in the interior in opposition to his assertion that it is absent in the interior. To prevent misapprehension I wish to state that the sentence on page 174 of my article reads as follows: "In Southwestern Colorado and Northern New Mexico, the Triassic is *also* present." On pages 173 and 174 I prove its presence in the interior (i. e. in South Park, north and west of the Sawatch Range, and in the Elk Mountains). Hence I do not use its presence in Southwestern Colorado and Northern New Mexico as a proof of its presence in the interior.

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* This volume, page 297.

The main points of my article are not touched by Prof. Stevenson, except one, viz: in regard to the Tertiary elevation of the Rocky Mountains, in which, as he says, we agree. As to his Carboniferous and Triassic upheavals we differ.

It is my intention to elaborate my views on the subject in the Report of the Survey for 1876.

Washington, D. C., April 18th, 1877.

6. *American Palæozoic Fossils.*—Mr. S. A. Miller of Cincinnati, Ohio, proposes to publish a catalogue of the species of American Palæozoic fossils arranged under each class in alphabetical order, giving name of author, date and place of publication, stratigraphical position, and etymology of words. The prospectus states that the volume will contain about 275 pages, and will be ready for sale by the 1st of June next. Price, bound in cloth, $3.00. Mr. Miller should be addressed at No. 8 W. 3d street, Cincinnati, Ohio.

7. *Palæontographica. Beiträge zur Naturgeschichte der Vorzeit, herausgegeben* von W. Dunker (of Marburg) und K. A. Zittel (of Munich).—It is proposed to issue the Palæontographica hereafter annually in volumes like the earlier, at a price not exceeding 45 shillings (English) per year, payable at the beginning of each year by Post Office order. The editors will have the assistance of W. Benecke, E. Beyrich, M. Neumayr, F. Römer, and K. von Seebach, as a committee of the German Geological Society. The 20 volumes of the first series, and 1 to 3 of the second, may now be had at 50 per cent deduction from the original prices, if applied for at once. The publisher is Theodore Fisher of Cassel, Prussia.

8. *Analyses of Japanese Porcelain-rocks*, by Henry Wurtz.—The paper upon porcelains and porcelain-rocks from Japan, by Mr. Wurtz, was noticed in the last number of this Journal (p. 320). The following are some of the analyses contained in the paper:—Analysis (1) is of a variety which has the native name *Tsuji-chuchi;* it is one of the most valuable of the porcelain-rocks found at Idzumiyama. It is a dull-white, porous, granular, coherent mass, not unlike coarse chalk in appearance, though much tougher. It adheres to the tongue, with a chalky taste. Several other varieties of somewhat different appearance, and employed in different ways in the manufacture of the porcelain, gave very nearly the same composition. This is shown in the analysis (2) of the variety Shiro-chuchi.

The only one which varies widely from these in chemical character is the kind called Kudaru-yama-chuchi, and for which Mr. Wurtz coins the English name, *Kudaruyamite.* Analysis (3) below gives its composition (G.=2·653), and (4) the same after the deduction of the opal-silica present. It is a pure white, soft, chalk-like substance, with slightly unctuous feel; under a magnifier it appears to be made up of small, amorphous, transparent grains. In water it falls to powder immediately.

	SiO_2	AlO_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	
1.	78·18	15·70	·66	tr.	·10	--	1·74	·55	2·52	= 99·45
2.	77·68	15·19	·89	·01	·10	·15	1·47	·51	3·33	= 99·33
3.	49·93	38·74	1·58	--	·21	--	1·44	·44	7·61	= 99·95
4.	47·95	40·82	1·67				1·77		7·79	=100·00

9. *On the Hermannolite of Shepard, and on the Samarskite of North Carolina*; by Prof. DELAFONTAINE. (Letter to J. D. Dana, dated Chicago, March 23, 1877.)—I have recently made an examination of some tantaliferous minerals of the United States, a brief account of which I offer now. Prof. Shepard sent me last summer a sample of his *hermannolite*, in which I was able to find only a large proportion of niobic acid, about 16 per cent of tantalic acid, and very doubtfully a little titanic acid. In one of his notes on this subject Prof. Shepard insists upon the difference in specific gravity between hermannolite and the niobite (columbite) from Brainard's. Two facts account for that: Brainard's niobite contains over 37 per cent of tantalic acid, as I ascertained from specimens kindly given to me by Mr. C. U. Shepard himself; furthermore, the crystals of hermannolite contain some foreign substance in the form of yellowish crystals, which I could not separate from the mass they were imbedded in.

In the Portland and Middletown (Conn.) columbites I found respectively 22·6 and 20 per cent of tantalic acid. A careful examination of the samarskite from Mitchell County (N. C.) has shown me that the brownish variety, with a less conchoidal fracture, looking somewhat like euxenite, contains about 25 per cent of *tantalic acid*, a small percentage of *thoria* and of *didymium*, in addition to the elements found by Hunt in 1852. The yttria includes also a little of the rosy earth with absorption spectrum, called *erbia* by Bunsen, Cleve and others, and more of the yellow earth described by Mosander under the name of *erbia*, but which, in order to avoid confusion, I call *terbia* (giving up the name *mosandria* which I proposed three years ago). The existence of that base is still denied by Bunsen and Cleve, but their conclusions I am further than ever from accepting. A monograph of its principal compounds will soon be published. All my endeavors to find Mr. Hermann's *ilmenium* in samarskite have proved unsuccessful as well as those of Marignac and Blomstrand, working on other material.

[The account by Prof. Shepard states that the hermannolite was found at a locality near the house of Mr. Cook (a dealer in minerals); but Mr. Cook informs us that there is no such locality, and that it must have come from the columbite locality, a mile distant from it.—EDS.]

III. BOTANY AND ZOOLOGY.

1. *On Right-handed and Left-handed Relations in Space.*—The following is extracted from J. Clerk-Maxwell's Treatise on Electricity and Magnetism, i, p. 23. "In this treatise, the motions of translation along any axis, and of rotation around that axis, will be assumed to be of the same sign, when their directions correspond to those of an ordinary or right-handed screw." "The combined action of the muscles of the arm when we turn the upper side of the right hand outward, and at the same time thrust the hand forward, will impress the right-handed screw motion on the memory more firmly than any verbal definition. A common corkscrew may be used as a material symbol of the same relation." "This is the right-handed system which is adopted in Thomson and Tait's *Natural Philosophy*, §243. The opposite, or left-handed system, is adopted in Hamilton and Tait's *Quaternions*."

It appears, therefore, that the view which "A. Gray, Darwin, and Bentham" are blamed for taking, is regarded as the natural one by Clerk Maxwell, Thomson, etc., among the mathematicians and physicists. For avoiding ambiguity, "Prof. W. H. Miller has suggested to me that, as the tendrils of the vine are right-handed screws, and those of the hop left-handed, the two systems of relations in space might be called those of the vine and hop respectively," Maxwell, l. c. This botanical illustration is readily understood, but is not altogether a happy one. By "the vine," everywhere out of the United States, the grape-vine (as we call it) is meant. Now the vine-tendril hardly coils except when it has laid hold, and then, when half the coil is in one direction the other is necessarily in the reverse. And the hop has no tendrils: the meaning is that its *stem* in climbing moves from *right to left*, i. e., of the outside observer; while in the larger number of climbers (of which Bindweed, *Convolvulus*, etc., is the better type) the movement is in the opposite direction. But the terms "hop-system and vine-system" are obviously impracticable in descriptive botany. "With the sun" and "against the sun"—the terms which Darwin commonly uses—might perhaps be made manageable in botanical description; but the term heliotropic is used in a different sense and connection, and anti-heliotropic for the counterpart is too long and awkward a word. *Eutropic* and *antitropic* might serve the purpose, and if agreed upon would do away with the ambiguity of the terms right and left, as affected by the position of the observer, whether within or without the circle or coil. Thus, in saying that the hop in twining "follows the course of the sun," it matters not whether the coil and the apparent path of the sun be regarded from the outside or from the inside. A. G.

2. *Observations sur l'enroulement des Vrilles*, par M. CASIMIR DECANDOLLE. Extr. Archiv. des Sciences de la Bibliotèque Universelle. Jan., 1877. pp. 13.—The double turn of the helix in attached tendrils excited the author's attention, but he finds, as

would be expected, that this is a purely mechanical result and a necessity of the situation. He neatly demonstrates this, by allowing a tendril to seize by its free tip some solid object suspended from a thread, the torsion which takes the place of the inverse turns of the coil in the ordinary situation. The lower side of the tendril is always interior in the coil. This comes from the arrangement of its fibrous bundles, which form a circle only at the base of the tendril, but above this only an arc, open on the upper side; this upper cellular portion is accordingly more affected by turgescence and can grow longer than the lower. Tendrils which remain free are less vigorous than those which gain attachment; vigor, as well as increased growth in thickness, is developed by use. The difference in the direction of the coiling, whether from right to left or left to right (or as we should like to say, whether *eutropic* or *antitropic*) does not depend upon anything in their anatomical structure, but appears to be in some way determined by the plant. A series of experiments with detached tendrils floated on water, or with the cut end immersed, and with tendrils divided into pieces (which preserve their vitality and continue their action) show this; when fixed by one end and free at the other, or at least when fixed by the summit only, they coil nearly as often in one direction as the other. The elongation of the different portions of a tendril ceases first at the base; it regularly augments from base to apex. A. G.

3. *Date of the parts of Elliott's Botany.*—Referring to our note in the January No. of this Journal, it is worth recording that the first fasciculus actually ended, as was supposed, on p. 96. No. 5 consisted of pages 401 to 496, and bears the date of 1817. No. 6 contained pages 497 to 606, and is dated 1821. This information is obtained from the inspection of copies of those parts in their original state, and is obligingly supplied by Mr. F. B. Dexter, of the Yale College Library. A. G.

4. *Onion-Smut*, by Prof. W. G. FARLOW.—A pamphlet of 15 pages, with a plate, extracted from the 24th Annual Report of the Secretary of the Massachusetts State Board of Agriculture, Boston, 1877.—The smut in question is as yet unknown out of New England, and there it has not long been known; but of late it has done much damage to the onion-crop at Wethersfield, Conn., and in Essex Co., Mass. The fungus proves to be a peculiar species of the *Ustilagineæ*, to which that of Indian Corn (*Ustilago Mayidis*) and of Rye, etc., belong. This onion-smut is most like that of Rye, *Urocystis occulta*, and a figure of an affected rye-stalk is given in this paper along with that of the onion. The fungus of the latter was named, by Mr. Frost of Brattleboro, *Urocystis Cepulæ;* but it is now for the first time described and illustrated by Prof. Farlow. The subject had, however, been taken up by "the microscopist of the Agricultural Department at Washington," in the Report of 1872; but Prof. Farlow intimates—what we should have expected—that the account and figures there given throw no light upon the matter. The remedy suggested is to burn over the fields where the smut has appeared, and not to raise onions

upon it again for three or four years at least. The smut is thought unlikely to be conveyed or introduced with onion-seed. A. G.

5. *Botanical Instruction at Harvard University.*—In the course of summer instruction in science for 1877 (which commences July 6) both botanical courses are to be given at Cambridge. Formerly, while Prof. Goodale's instruction in Phænogamic Botany was given at the Botanic Garden, that on Cryptogamic Botany, by Prof. Farlow, was given at the sea-side. This is now to be given at Cambridge, whence collecting excursions can readily be made to good points on the shore. As it may be useful to call particular attention to this unique opportunity of obtaining a knowledge of the lower Cryptogamia, we copy the portion of the general circular which relates to Prof. Farlow's course. Prof. Goodale's course on Phænogamic Botany is already well known. But those who seek information respecting it should apply for the circular issued by the University.

"*Cryptogamic Botany.* The course will begin on Friday morning, July 6th, and continue six weeks. Microscopes and all necessary equipments are provided by the University, but students are expected to bring sharp razors, razor strops, dissecting needles, slides, and covering-glasses. No provision, however, is made for drying and preparing specimens other than microscopic. A knowledge of the rudiments of Phænogamic Botany is required of those taking this course, or in case of those wishing to pursue the subject in connection with Zoological studies, a practical acquaintance with the working of the compound microscope. A general course of lectures will be given upon the structure and development of Thallogens, and on one day of the week an excursion will be made either into the country or to the sea-shore.

Laboratory instruction will be given every day except Saturday, and the method of examining Fungi and Algæ and the manner of making microscopic preparations will be taught. Illustrations of the structure, and, as far as time will allow, of the development of the principal orders of Fungi and Algæ will be afforded each student, and an opportunity will be given to become familiar with the more common moulds, blights, and with a few agarics. Students who have attended a previous course can pursue more in detail any branch of the subject they may prefer. Under certain restrictions, students may consult the extensive cryptogamic collections and library of the University."

We believe that the announcement may now be made that Prof. Farlow's instruction in Cryptogamic Botany in the University proper, will hereafter be given at Cambridge, instead of at the Bussey Institution at Jamaica Plain, a change greatly to the convenience and advantage of the students which this important course of study is likely to attract. Dr. Farlow was a pupil of De Bary and of the late M. Thuret. With the facilities now afforded, he should establish the school of Cryptogamic Botany in this country which has long been needed.

At the Bussey Institution it is expected that a very full elementary course of instruction on Botany and Vegetable Physiology, in relation to rural affairs, horticulture, agriculture, etc., will be given throughout the year, by lectures and laboratory-teaching. This course will be conducted by Profs. Goodale, Farlow, and others.

6. *Classification and Terminology in Monocotyledons*, by GEORGE BENTHAM.—A paper of 30 pages, and with three plates, closing the 15th volume of the Journal of the Linnean Society, 1877. An arrangement of the orders is sketched, which, being employed in the *Flora Australiensis*, will doubtless be adopted in the new *Genera Plantarum*, unless in the mean while reason appears for modifying it. They are grouped in four alliances, or cohorts, beginning with those bearing the most complete and differentiated flowers, thus: Alliance 1, EPIGYNÆ, with inferior ovary and mostly biseriate perianth. The four sections are based upon habit and the seeds, in which rather more than usual rests upon the presence or absence of albumen. *Hydrocharideæ*, aquatic plants, with regular flowers and exalbuminous seeds, begin the series. The *Scitamineæ*, which follow, by an awkward misprint or slip, are said to have *ex*-albuminous seeds. As they really accord in this regard with the fourth and larger section which begins with the *Irideæ* and ends with the *Bromeliaceæ*, they might as well be placed after the third section, which consists of the *Orchideæ* and *Burmanniaceæ*.

Alliance 2, CORONARIÆ, with superior mostly syncarpous ovary, albuminous seeds and mostly biseriate perianth. Its first section, with perianth of both series petaloid [a character not without exception], consists of the *Liliaceæ* and their allies, down to the *Pontederiaceæ*. In the list of suborders of *Liliaceæ* "Agaveæ" has by accident been printed instead of *Aloineæ*. A second group has the outer perianth calycine or none, and the inner petaloid; *Philydraceæ*, *Xyrideæ*, *Commelynaceæ* (but not *Trillium*). The third group has perianth of both series calycine, and includes the *Junceæ* and *Palmæ*.

Alliance 3, NUDIFLORÆ, with free ovary apocarpous, monocarpellary, or rarely syncarpous; the perianth either none or reduced to a scale under each anther. *Alismaceæ* are exceptional; but their association with *Aroideæ* and *Naiadaceæ* seems natural.

Alliance 4, GLUMALES, contains two groups; the first with ovary often more than one-celled, and ovule pendulous; *Eriocauloneæ*, *Centrolepideæ*, *Restiaceæ*. The second, with one-celled ovary and erect ovule, *Cyperaceæ*, *Gramineæ*. The schedule is followed by a series of critical remarks and explanations.

The homology of the parts of the blossom in *Xyris* is reviewed, and better interpreted; the two outer so-called perianth-segments are shown to be bractlets; what was taken for a third segment, within the two outer, is shown to be the representative of the whole exterior perianth, mostly caducous; as to the remaining or tubular perianth no conflict has arisen.

The chief interest of the latter part of this paper is found in the exposition of the homology and terminology of glumes, etc., in *Cyperaceæ* and *Gramineæ*,—a just account of which can hardly be given in a brief abstract. Mr. Bentham prefers to use the term glume in *Cyperaceæ* as well as in Grasses. While highly approving the systematic labors of Boeckeler, of Berlin, in the former order, he criticises some parts of his terminology and morphology. Mr. Bentham's own conclusions correspond with those adopted in this country as to the structure in *Cyperaceæ*. As to *Gramineæ* our prepossessions were all in favor of Robert Brown's view, adopted by Kunth and most agrostologists, so that little attention was paid to the view proposed in our author's Handbook of the British Flora. We have not room here to exhibit the proposed view and the aptly-stated reasons for its adoption. Suffice it to say that we are convinced by the latter, and that the adoption of this view will simplify the study of Grasses, and bring the homology of the gramineous spikelet into full accordance with that of *Cyperaceæ* and other orders. The exposition given is certainly well calculated "to enforce a principle generally admitted, but unfortunately too much neglected by speculative botanists, viz: that to be really useful, descriptions should, in clear and intelligible language, not only enable the reader to identify the plant he has in hand, but call his attention specially to those characters which may indicate its real affinities, the homologies of its parts, and any other relations they may have. But for this purpose it is necessary that the author should distinguish descriptions of plants from theoretical explanations, that he should, in terms the most capable of strict definition, describe only what the observer may actually see, not what it may be theoretically imagined he ought to see, reserving his theories for comments upon what has actually been observed." A. G.

7. *The Various Contrivances by which Orchids are fertilized by Insects;* by CHARLES DARWIN. Second edition. New York.—The first edition of this interesting work, which appeared in 1862, was reviewed at that time in this Journal, and served as the basis upon which to display the curious adaptations of some of our North American Orchises. This second edition, to which much is added, has been reprinted by D. Appleton & Co. of New York, and so our botanists will soon be familiar with it. In a future number we propose to give some account of the volume, along with a forthcoming one upon a cognate subject by the same author. A. G.

IV. ASTRONOMY.

1. *The New Star in Cygnus.*—A remarkable stellar outburst, similar to that which appeared in *Corona Borealis* in May, 1866, was first noticed by Dr. Schmidt, at Athens, on the 24th of November last, at 5.41 P. M., in the constellation *Cygnus*, then near the zenith. The new star, when first observed, was of the third magnitude, and of a yellow color, near ρ *Cygni*, where Dr. Schmidt is sure that no corresponding object existed on the evening of November 20. The sky was overcast at Athens on the three following days, and most probably the outburst appeared at

its full brilliancy in the interval between November 20 and 24. At midnight on the latter day the light of the star was of greater intensity than that of *η Pegasi*, noted of the third magnitude by Argelander. Its position does not appear to be recorded in the usual catalogues of small stars; certainly not in those of Lalande, Weisse's Bessel, Bode, D'Agelet, or in the Durchmusterung of Argelander. From an observation made by Mr. Hind at Mr. Bishop's Observatory on December 13, its R.A. for 1876·0 is 21^h 36^m $50^s{\cdot}41$, and its N.P.D. 47° 43′ 21″·5.

Unfortunately, Dr. Schmidt's discovery was not immediately communicated to the Astronomer-Royal or to any other English astronomer, although a telegram was sent to Dr. Littrow, at Vienna, and probably to other Continental observers. The first information of the sudden appearance of the new star was received in England only in the second week in December, from the public notices inserted in the Bulletin International and Comptes Rendus. This neglect is much to be regretted, as there were eight favorable evenings at Greenwich before December 9, when spectroscopic observations might have been successfully made, and of these at least two were near the time of the star's maximum brilliancy. Principally for this reason, but also in consequence of almost continuous unfavorable weather afterward, very few observations of the star have been made in this country. When seen by Mr. Hind on December 13, it had receded to the sixth magnitude, and was without a trace of color. The observers in Paris were more fortunate in obtaining information, for the star was examined on December 2, during a brief interval of clear sky, by MM. Henry, Cornu, and Cazin, and estimated of the fifth magnitude. Under more favorable circumstances, on December 4, M. Cornu made some satisfactory observations of the spectrum of the star with the eastern equatoreal of the Paris Observatory, the magnitude on that day being estimated at 4·5. The spectrum exhibited eight detached bright lines on a luminous ground, with an almost complete interruption of the light between the green and the indigo. M. Cornu saw no dark lines; if they had existed they must have been very fine, and invisible owing to the faintness of the light.

Naming the bright lines according to their intensity by the Greek letters *α* to *θ*, their positions in the spectrum, in relation to those of certain elements, may be readily seen from the numbers in the following table determined by M. Cornu :—

	α	*δ*	*γ*	*β*	*ζ*	*η*	*θ*	*ε*
Observed	661	588	531	517	500	483	451	435
Hydrogen.........	656 (C)	---	---	---	---	486 (F)	---	434
Sodium	---	589 (D)	---	---	---	---	---	---
Magnesium	---	---	---	517 (*b* mean)	---	---	---	---
Coronal line	---	---	532	---	---	---	---	---
Chromosphere lines	---	587	---	---	---	---	447	---

M. Cornu remarks as an interesting fact, but one requiring confirmation, that there are several coincidences shown in the preceding table which have led him to the conclusion that the bright lines in the star-spectrum correspond exclusively with the principal lines in that of the chromosphere, and therefore that the light of the star possesses precisely the same composition as that of the Solar envelope. He says: "But the most curious result, which I give here with much reserve, but which it will be very interesting afterwards to verify, is the coincidence of the line γ, very bright in the spectrum of the star, with the green line $\lambda = 532$ (1474 of Kirchhoff's scale), observed in the spectrum of the Solar corona and in the chromosphere; the feeble band θ corresponds also with a band $\lambda = 447$ of the chromosphere; one is thus led to think that the line ζ corresponds rather with the bright line of the chromosphere $\lambda = 587$ (helium), than with that of sodium, 589. If this interpretation be correct, the bright lines of the spectrum of the star comprehend exclusively the brightest and the most frequent lines of the chromosphere."

The spectrum of the star has also been examined by Father Secchi, Dr. Vogel, and others, all of whom confirm generally the previous observations of M. Cornu. Several bright lines were seen by Dr. Vogel in the red, blue-green, and blue parts of the spectrum; bright bands were also visible in the yellow and green; but these may possibly be portions of a continuous spectrum seen bright by contrast with absorption bands, of which there were as many as eight or ten. The blue and violet were brighter than in most stars with band spectra. The bright lines C, F, and D_3 were visible; *b*, however, was probably not seen bright, but a bright line on the blue side was noticed, which may possibly be identical with a line which under peculiar circumstances is the brightest in the spectrum of hydrocarbon. One seen in the violet may be the third line of hydrogen. Dr. Vogel remarks that there are three other stars in *Cygnus* giving quite unique spectra.

By careful comparisons with several neighboring stars, Dr. Schmidt noted the gradual diminution in the intensity of the light of the star almost daily. The variations of magnitude are exhibited in the following table:—

November	24	3·0	Magnitude.	December	5	5·9	Magnitude.
"	25	3·1	"	"	7	6·3	"
"	26	3·1	"	"	8	6·5	"
"	27	3·2	"	"	9	6·6	"
"	28	3·8	"	"	10	6·5	"
"	29	4·7	"	"	11	6·7	"
"	30	5·0	"	"	12	6·7	"
December	1	5·2	"	"	13	6·8	"
"	2	5·4	"	"	14	6·9	"
"	3	5·6	"	"	15	7·0	"
"	4	5·8	"				

At the end of the year the star was still about the seventh magnitude, and of a decidedly orange color, with a reddish tint. —*Monthly Notices Astron. Soc.*, Feb., 1877.

2. *Planets recently discovered.*—The names, orbits, times of discovery, and names of discoverers of the minor planets found since the beginning of 1876, are given in the following table. The orbits are from the circulars to the Berliner Jahrbuch.

PLANETS RECENTLY DISCOVERED.

No.	Name.	Time of Discovery.	Discoverer.	Mean Dist.	Angle of Eccent.		Incl.		Long. of Node.		Long. Per.	
					°	′	°	′	°	′	°	′
158	Coronis,	Jan. 4, 1876	Knorre	2·9901	16	59	1	23	282	49	355	10
159	Aemilia,	Jan. 26, “	Paul Henry.	3·1253	6	38	6	5	135	5	100	40
160	Una,	Feb. 20, “	Peters.	2·7542	3	39	3	32	12	3	191	16
161	Athor,	Apr. 16, “	Watson.	2·3760	7	38	9	10	18	33	312	56
162	Laurentia,	Apr. 21, “	Pros. Henry.	3·0211	9	31	6	3	38	15	147	44
163	Erigone,	Apr. 26, “	Perrotin.	2·3507	8	34	4	41	159	0	93	17
164	Eva,	July 12, “	Paul Henry.	2·5525	18	42	24	48	77	27	2	46
165	Loreley,	Aug. 9, “	Peters.	3·1286	4	10	11	10	304	1	282	24
166	Rhodope,	Aug. 15, “	Peters.	2·7199	13	48	11	41	129	15	30	52
167	Urda,	Aug. 28, “	Peters.	3·2186	18	11	1	42	170	7	32	39
168	Sibylla,	Sept. 28, “	Watson.	3·3781	3	51	4	35	209	36	5	43
169	Zelia,	“ “	Pros. Henry.	2·3580	7	30	5	31	354	35	326	35
170		Jan. 10, 1877.	Perrotin.	2·5510	3	44	14	21	301	18	98	37
171		Jan. 13, “	Borrelly.	3·1472	8	8	2	30	100	54	151	21
172		Feb. 5, “	Borrelly.	2·3795	5	46	9	41	331	48	326	17

To the planet (150) the name *Nuwa* has been given. The observations of (149) *Medusæ* and (155) *Scylla* were not such as to furnish reliable elements of their orbits.

To the planets recently discovered might be added the two rediscovered by Palissa, viz: (66) *Maia*, (Sept., 1876,) not seen before since 1861, the time of its discovery by Tuttle, and (107) *Camilla*, (March, 1877,) not seen before since 1868, when discovered by Pogson. Of the first 140 planets between Mars and Jupiter, the following have been seen only at the opposition near the time of discovery, viz: (99) *Dike*, (125) *Liberatrix*, (132) *Aethra*, (137) *Meliboca* and (139) *Juewa*. The following have been observed at one opposition subsequent to the time of discovery, viz: (66) *Maia*, (104) *Clymene*, (107) *Camilla*, (123) *Brunhilda*, (131) *Vala*, (133) *Cyrene*, (134) *Sophrosyne*, and (135) *Hertha*. Seven others of the 140 have been observed at two oppositions subsequent to that of discovery, and 120 at four or more oppositions including that of discovery. H. A. N.

3. *Publications of the Private Observatory of Lord Lindsay, Dun Echt (Aberdeen).*—Vol. i, of this series has just been issued in quarto form. It is privately (and extremely well) printed and has been liberally distributed to astronomers in Europe and America. Its title page well describes its contents:—“A Summary or index of the measurements (of double stars) in the ‘stellarum duplicium et multiplicium mensuræ micrometricæ,’ F. G. W. Struve, 1837, and ‘Additamentum in F. G. W. Struve mensuras micrometricas stellarum duplicium’ (1837), including all the stars in the ‘Synopsis observationum de stellis duplicibus, in specula Dorpatensi, annis a 1814 ad 1824, per instrumenta minora perfectum’ and in the ‘II. mensuræ micrometricæ’—reärranged in order of R. A., and the positions brought up to 1875.”

Each page contains thirteen columns and everything relating to each star is found in its horizontal line or in a foot note. Column 1 contains Struve’s number, column 2 the page in *Mens. Mic.*

where the star is to be found, column 3 the synonyms, columns 4 and 5 the R. A. and δ for 1875·0, column 6 the lowest and highest magnifying powers used by Struve, column 7 the mean date of observation, columns 8 and 9 Struve's distance and position angle, columns 10 and 11 give the magnitude and color of the principal component A, columns 12 and 13 the same data for B. Appended is a table of the precessions in declination for *ten years* and a diagram from which the variable part of the precession in R. A. for *ten years* in minutes of time can be taken by inspection. Double star observers will find this a most useful and valuable work. E. S. H.

4. *La Luce Zodiacale, sue Leggi e Teoria Cosmico-Atmosferica, dedotte dalle Osservazione di G. Jones*, per il P. A. SERPIERI, D. S. P., Direttore dell' Osservatorio Meteorologico di Urbino. Palermo, 1876. 4to, pp. vi, 113, with 4 plates.—This is a reprint, from the Journal of the Italian Spectroscopists, of an elaborate memoir chiefly founded upon the observations of the Rev. George Jones, of the U. S. Navy, but with the use of many observations derived from other sources. The author, rejecting the now commonly received theory of the Zodiacal Light, which attributes its luminosity to sunlight reflected from innumerable small meteoric bodies, comes to the conclusion that it is a purely terrestrial phenomenon, in the nature of an aurora, differing from the polar auroras merely in its having a particular fixed position and by its permanence. He supports this conclusion by a variety of arguments, prominent among which is the supposed occurrence of the auroral line in the zodiacal spectrum, as reported by a number of observers, and he considers the continuous spectrum seen by many other observers as a thing of mere occasional and fortuitous nature. Now, in point of fact, no one making systematic and continuous, observations for a length of time has always found the auroral line present, and the assumption of its presence in the spectrum of the zodiacal light rests chiefly on a few isolated instances, while on the other hand a continuous spectrum is always visible. Again he regards the polarization of the light, determined by careful observations of at least two persons continued for a considerable period of time, as an accidental circumstance, and not as a permanent characteristic. The admission of the reality of this and the continuous spectrum would be fatal to the auroral theory, which even otherwise finds few supporters. Although the author's conclusions may be questioned with good reason, the volume is a valuable contribution to the literature of the zodiacal light, bringing together as it does many excellent observations, and containing interesting particulars respecting the physical aspects of this much discussed phenomenon. A. W. W.

5. *Comets in* 1877.—There have been thus far this year three new comets discovered. a decided contrast to the barrenness in discoveries of the last four years.

(1.) Borrelly at Marseilles found a telescopic comet Feb. 8th, in Ophiuchus. Approximate elements are, $\pi=174° 35'$, $\Omega=187° 20'$, $i=153° 2'$, $\log q=9·90712$.

(2.) Borrelly discovered a second comet about the 6th of April.

(3.) Mr. Lewis Swift at Rochester, discovered on the evening of the 11th of April, a very faint comet in the head of Cassiopeia. The discovery was telegraphed the same evening to Professor Henry and to the Associated Press, but for some reason notice seems not to have been sent to Europe. This enabled Borrelly on the 14th to announce his later discovery of the same comet.

6. *Observations of Comets* 1877*b*. *and* 1877*c*. *at the Observatory of the Sheffield Sci. School, made by* W. BEEBE, H. A. HAZEN, and T. A. SMITH.—Comet 1877*b*. was observed here at the dates given below. At first it seemed a round nebulous mass, about 5′ in diameter, at first slightly but later more plainly condensed at the center, clearly defined on the side toward the sun, and fading very gradually in the opposite direction, though without any elongation that could be properly called a tail. But on the 21st, after a period of cloudy weather, the comet had become much brighter, with a well-defined nucleus. Two tails were also visible, one extending nearly west along a circle of declination about 20′, and one southwest making with the first an angle of about 60°, the whole forming a kind of fan-shaped tail. The following observations were made with a ring micrometer constructed by Professor Lyman. It differs from the usual form in that it consists of four concentric rings, the largest about a degree, the smallest about 8′, in diameter. By this arrangement any or all of the 8 circles can be used for comparisons, and selections may be made for the best observations, whether for R. A. or dec. Power=60. In absence of a chronograph, or of a clock in the tower, an assistant noted time from a portable chronometer. The names of the first three comparison stars are uncertain.

New Haven m. t.				(C—S), Δα		(C—S), Δδ		Comp. star.	No. Comp.
	h	m	s	m	s	′	″		
April 7,	16	18	38	+2	17·86	−17	19·15	43397 LL.	11
9,	15	46	31	+6	36·97	−18	52·90	43247 LL.	14
11,	15	26	5	+4	12·09	--	----	43417 LL.	12
12,	14	41	10	−8	8·89	− 9	4·25	43890 LL.	6
12,	15	26	8	−8	8·92	−12	44·90	43891 LL.	13
15,	--	--	--	6	54·50	--	--	·44026 LL.	6

Swift's comet (1877*c*.) was seen here on the evening of the 12th, and the observation then made is perhaps the earliest exact measurement of its place. The comet appeared to be a faint elongated bit of haze less than 1′ broad and was 5′ or 6′ long. With powers of 40 to 200 (object-glass = 8¾ in.) no trace of nucleus was seen or other distinguishing mark. The comet passed centrally over a 10 mag. star, which at first was taken for a nucleus. The place of this star was taken as that of the comet. The comet was again seen on the 22d of April.

New Haven m. t.				(C—S), Δα.		(C—S), Δδ.		Comp. Star.	No. Comp.
	h	m	s	m	s	′	″		
April 12	9	2	0	−4	43·32	+ 7	51·2	*a*	7
"	9	2	0	−9	16·18	+11	0·2	1951 LL.	5
22	15	19	29	+2	40·00	−15	45·0	*b*	5

App. place, Apr. 22, R. A. $2^h\ 28^m{\cdot}5$. Dec. +60° 18′·5. W. B.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Notes on the Appearance and Migration of the Locust in Manitoba and the Northwest Territories, Summer of* 1875; by GEORGE M. DAWSON. 18 pp. 8vo. (From the Canadian Naturalist.)—Mr. Dawson states that in 1875 the hatching of the locusts in Manitoba began in favorable places May 7th, and became general May 15th. The most northern locality was Manitoba Lake, in latitude 51°. The movement began in July, and was most general during the latter half of the month and first of August; and the direction was southeast or south, the insects apparently using, by instinct, the winds that favored their purpose. Many were carried into a country of thick woods, where they did little harm, and few reached Minnesota. Others passed over Crookston, Polk County, Minnesota, and Fort Totten, Dakota; and probably the Sioux City locusts, mentioned by Mr. C. V. Riley, came from Manitoba.

Other swarms of locusts came from the south across the 49th parallel, with a wide front stretching from the 98th to the 108th meridian, which differed from the natives of Manitoba, inasmuch as they arrived before the latter were mature. These were "the extreme northern part of the army returning, going northward and northwestward, from the States ravaged in the autumn of 1874." They appeared at Fort Ellice on the 13th of June, and at Qu'apelle Fort on the 17th; about Swan Lake House, their most northern point, July 10th. Fort Pelly, farther west, and nearly a degree farther south was reached July 20th. About seven days were occupied in the journey from the latter place to Swan River Barracks, a distance of only ten miles.

Mr. Dawson concludes that the planting of belts of woodland would effect in time a general and permanent amelioration of the grasshopper plague, since they usually avoid such belts,—their invading the forests in 1875 being perhaps due to the insects having "lost their reckoning."

The journey southward was regardless of the direction from which their parents had come the preceding year; and those of Nebraska, Missouri, Kansas and Texas, flew northward and northwestward, returning on the course of their parents which had flown southeastward from that quarter; and this movement extended over an immense area from the northern borders of Texas almost to the Saskatchewan River. The normal direction of flight is toward the hatching grounds of their parents, so that two years seem to be required to complete the migration cycle. The fact that the young, while amenable to the migratory tendency, show a determination to exercise it in a direction exactly the opposite of the preceding generation is most remarkable.

As to prevention, the methods proposed are the cultivation and preservation of forest trees; the protection of the prairie grass until the appropriate time for destroying the young insects in the hatching grounds by fire; the protection of insect-eating birds.

2. *The Telephone.*—During the month of April, "telephonic concerts," at which large audiences were present were given in Boston and Washington, through musical instruments played in Philadelphia. At both, the music, although rather feeble in tone, was distinctly heard by the audience in all parts of the hall. At the Washington concert, April 9th, eight airs, commencing with "Home, Sweet Home," were listened to "with profound attention, and the conclusion of each tune was enthusiastically applauded. The intonations were remarkably clear and perfect, exciting additional wonder and astonishment." Professor Gray stated the new fact that the music (or electric waves of sound) was also conveyed, by induction, along other parallel telegraphic wires, attached to the same poles—a fact observed in the Washington office of the New York Associated Press, where a number of the tunes played in Philadelphia were distinctly heard on a "relay" used in the office, which had no connection whatever with the wire that was attached to the telephone. The tones thus conveyed, although not loud, were distinctly heard at a distance of several yards from the instrument.—*N. York Times of April* 10.

3. *Scientific Expedition to the Rocky Mountain Region from Williams College.*—A party, limited to about fifteen in number, under Prof. Sanborn Tenney of Williams College, will start for Colorado, Southern Wyoming and Utah, immediately after the close of the college year, and return about the 1st of September. Explorations will be carried on, and collections made in all departments. It is expected that there will be instructors in different departments. Prof. Tenney was over the region three or four years since.

4. *Scientific Expedition and Summer School of Butler University, Irvington, Indiana.*—This expedition leaves Indianapolis and St. Louis about June 20th; and will go from there by railroad to the Iron Mountain region and through Arkansas, to Dallas, Texas, stopping wherever there are objects of interest to be seen or collected in Geology and Natural History. It will leave Dallas on the return about August 1st, and reach Nashville, Tenn., at the time of the meeting of the American Association. Dr. D. S. Jordan, Prof. I. A. Myers, Prof. W. R. Dudley, Mr. E. R. Copeland and Mr. C. H. Gilbert are the instructors to accompany the expedition. Tuition $25.00 to be paid before starting. Each person will pay his own expenses and have his own collections. Probable expense of railroad fare to Dallas and return, $50 to $65; board seven weeks about $35. "Lady students will be received if five or more make application." Applications should be made to Prof. John A. Myers, Irvington (near Indianapolis), Indiana.

5. *Report of the Chief of Engineers to the Secretary of War, for the year* 1876. In three Parts, making three thick volumes 8vo, with many maps and plates. Washington, 1876.—Besides the details with regard to the surveys and improvements in rivers, harbors and lakes carried on, in the various States, the Report contains much of scientific interest. The report of General Q. A.

Gilmore on the Channel of the Entrance to Cumberland Sound discusses the formation and growth of bars. It states that the bar (Fernandina bar) at the entrance to this Sound, is seven miles long, and is made and changed from time to time, through the combined action of the winds and waves, and not by the sediment of the discharging streams; that it is a combination of a *drift-bar* (formed by driftings of sands along the shores through wind-made currents), and a *wave-bar* (made by the waves), and is not a *delta-bar* (or one largely due to river detritus).

Lieutenant Smith reports on the practicability of a Canal across Florida, with reference to a reservoir on the summit-level. He calculates, from the mean temperature of Florida (about 70°) and the dewpoint (55°), by using Dalton's law, that the loss of water by evaporation would be 7·458 inches per month. In connection, he cites the fact that at London the loss per month is about 6 in. (Dr. Halley); at Montmorenci, France (Mr. Cotte), 5·315 in. for an ordinary summer month; at Languedoc Canal, 5·33 in. (Mr. Pinn); at Baltimore, 6·72 in. (J. J. Abert); at Morris Canal, 6·375 in. (Board of Engineers). The loss from filtration is made to be about fourteen times that from evaporation. He calculates that about one-fourth of the rain-fall can be made available—one-third being the usual allowance, in the more northern States, and 40 per cent the result of the experiments of Mr. J. B. Jervis with reference to the Chenango Canal, New York.

In addition to other sources of supply that of water of infiltration is considered. Lieut. Smith found, on trials, that water stood in shafts in the sandy soil up to within five feet of the surface during the months of July, August and September, and into November, except portions of July and August, when it was about a foot higher; that the source could be relied on during the three following months; but from then until the rains begin in June, the country is too dry for water from this source. It is finally concluded that the amount that may be depended on from infiltration is more than half that available from the rains, and about two-thirds more than the canal would require.

The Report contains also the valuable paper of General Warren, on the Fox and Wisconsin Rivers, noticed at page 132 of this volume; Notes on European Surveys, compiled under the direction of General C. B. Comstock, occupying 90 pages, giving the organization of geological surveys as well as topographical, and scales of maps, etc., with plates showing style of work; also, the report of Lieut. Wheeler, of the geographical surveys west of the 100th meridian, a notice of which is deferred to another number; the Report of Capt. Ludlow, already noticed on page 228, besides others.

6. *Height of "West Hills," Long Island.*—We have evidence that the height given by the Coast Survey for the "West Hills," 383 feet, was based on determinations that set aside entirely the doubt expressed on page 235 of this volume.—Eds.

7. ***Strength and Determination of the Dimensions of Structures of Iron and Steel with reference to the latest Investigations.*** An

Elementary Appendix to all text-books upon iron and steel construction; by Dr. JACOB J. WEYRAUCH, Prof. Polytech. School at Stuttgart. Translated by A. JAY DUBOIS, Ph.D., Prof. Civ. and Mech. Engineering, Lehigh University, Penn., with an Appendix by R. H. THURSTON, A.M., Prof. Mech. Eng., Stevens Inst. Technol., Hoboken, N. J. 210 pp. 8vo, with four lithographed plates. New York. 1877. (John Wiley & Sons, 15 Astor Place.)—Dr. Weyrauch's work has special importance in this bridge-building country. It treats of the method of dimensioning in iron and steel structures, explains Wöhler's important law, sets forth a new and improved method based on formulæ original with Prof. Launhardt and the author, and presents practical directions and various experimental results, a knowledge of which is essential to safe construction. The translation was made by Professor DuBois, at the request of the author.

8. *The Chemist's Manual: A practical Treatise on Chemistry, Qualitative and Quantitative analysis, Stœchiometry, Blowpipe Analysis, Mineralogy, Assaying, Toxicology, &c., &c.;* by HENRY A. MOTT, Jr., E.M., Ph.D., &c. 625 pp. 8vo. New York, 1877. (D. Van Nostrand).—This work is a compend of chemical facts and principles. The author has shown skill in the selection of his materials, and has derived them generally from the latest authorities. Many useful tables are introduced, as of Trautwine's specific gravities and weights; formulæ of frequently occurring substances arranged alphabetically; the table of alcohols in atomic series; poisons and antidotes, etc.; Mendelejeff's classification of the elements, reproduced from Watts's second supplement. Under quantitative analysis, are schemes and specific instructions for the analysis of the more frequently occurring commercial products, and in organic chemistry for wine, milk, sugars, both chemical and optical, with much that is not found condensed elsewhere in a form so conveniently accessible. B. S.

9. *Astronomical Myths based on* FLAMMARION'S *History of the Heavens;* by JOHN F. BLAKE. 432 pp. 12mo, with plates and wood-cuts. London, 1877. (Macmillan & Co.).—The title of this work hardly does it justice; for while containing astronomical myths, it gives in a popular way much of the early history of astronomical ideas, and something of early notions in geography. The chapters on the Pleiades is especially interesting, it bringing out much on the year and festival times of the ancients, and on the astronomical knowledge of the Egyptians and purposes of the pyramids. It has chapters also on the Zodiac; the origin of the Constellations; Eclipses and Comets; Astrology; time and the Calendar; and many other subjects, all of which are treated in a way to instruct and entertain.

The Electric Bath; its medical uses, effects and appliances, by George M. Schweig, M.D. New York: G. P. Putnam's Sons. 1877. pp. 134, 12mo.

Lecture Notes on Elementary Inorganic Chemistry; by E. S. Breidenbaugh, A.M., Prof. Chem. and Min. Pennsylvania College at Gettysburg. 72 pp. 8vo. Gettysburg, 1871.

Interpolation and adjustment of Series; by E. L. DeForest. 52 pp. 8vo. New Haven, 1876.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLIII.—*An account of the Discoveries in Vermont Geology of the* Rev. AUGUSTUS WING; by JAMES D. DANA.

[Continued from page 347.]

IN the preceding part of this paper the discoveries have been announced of *Trenton fossils* in crystalline limestone in North Castleton, Hubbardton, and Sudbury, within the area of the "great central slate-belt;" in East Cornwall just east of the belt; east of the village of Shoreham; in Eastern Orwell; in Middlebury, and north of East Cornwall—indicating a north-and-south area of Trenton limestone either side and underneath the slate, and showing the slate to be probably the Hudson River shales; of *Chazy fossils* at West Rutland; in East Cornwall; northeast of the village of Orwell; in West Cornwall; in North Cornwall at Ellsworth Ledge; at Weybridge Upper Falls northwest of Middlebury; of *Quebec fossils*, south of the East Cornwall locality of Trenton fossils, and in North Cornwall at Ellsworth Ledge; of *Calciferous fossils* near the borders of West Cornwall at Bascom's Ledge; in Northeastern Shoreham at Mutton Hill, and also in another fold near by (affording a small species of *Orthoceras*, etc.); near the border of West Cornwall at Bascom's Ledge, and at Barbour's Ledge in South Bridport.

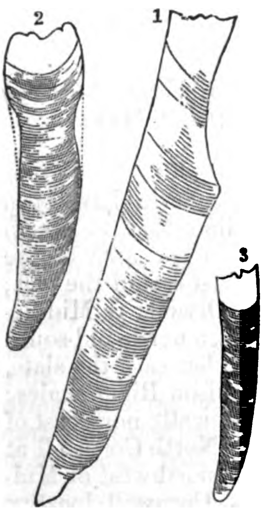
The Eolian limestone extends north through Middlebury and New Haven and terminates in Monkton, and affords other fossils in its northern portion.

6. *Northern Middlebury, New Haven, Monkton.*

About two miles north of Middlebury, a few rods east of the road running by Messrs. Hammond's to the Severance (or Old

Middlebury) Marble Quarry, half a mile west-by-south from the quarry, across a small stream, there is a thin bed of limestone dipping to the east 70° or 75°, underlaid on the west by six or eight feet of dark fine-grained quartzyte holding *Scolithi.* At this place ten or twelve specimens of a small *Orthoceras* occur, weathered out over the exposed surface of limestone near the place of contact with the quartzyte. The Orthocerata are tapering in form, three to five lines in diameter and one to two inches long, and have very fine close septa. The species is very much like the Calciferous *Orthoceras* figured by Hall in the New York Report.

14–16.



I visited this locality, on my excursion with Mr. Wing, and found his description right; the specimens are beautifully distinct although only worn sections. Expecting that Mr. Wing would describe the Orthoceras, and also hoping that I should receive from him a specimen (which only long working with a quarryman's tools could safely dig out), I took no satisfactory notes at the time. Through the kindness of Professor H. M. Seely, I have had "squeezes" from three of the specimens, showing well the character of the septa, and have further learned that the number of septa is from ten to thirteen in a quarter inch, that is forty to fifty-two in an inch; and I have also received drawings made on the spot by Miss Parker. The accompanying three figures are from these drawings and the squeezes. They are natural size; and Professor Seely observes that there are indications, though doubtful, that the upper end of No. 1 may have been half an inch longer. The figures are restorations only in having part of the septa more entire than in the specimens.

They show that the species is much like *Orthoceras primigenium* Hall, but that part have a slight curve. Mr. Wing's earliest notes on this locality among those in my hands, occur in a letter dated October, 1867.*

Half a mile northwest of the Orthoceras locality and two and a half miles northeast of Middlebury village, and apparently in the same formation with the last, there are specimens resembling *Ophileta compacta;* there was also found here a large *Maclurea.* "The figure here given is correct as to size and general form, though not having the grace of the original."

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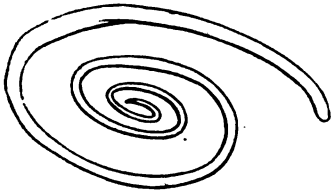
* I repeat here that the paragraphs in smaller type consist of remarks by the compiler of this paper, and of facts from other sources.

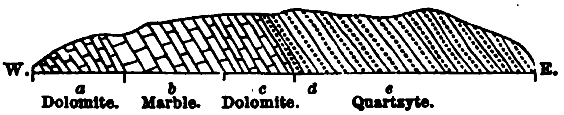
17.



About a mile southwest of the Middlebury quarry and thirty or forty rods west of Mr. E. Kirby's residence, in an old orchard, several distinct convoluted shells were seen on a dark siliceous limestone dipping west. The beds are probably Calciferous.

The quartzyte near the old Middlebury Marble Quarry above-mentioned extends northward into the town of New Haven to New Haven River, a distance of about two miles. The following figure represents a section taken south of New Haven River on the southern border of the town of New Haven. There are in succession, going eastward along the lines of section, 150 feet of dolomite (*a*); 200 feet of marble (*b*); 150 feet of dolomite (*c*); 10 feet of gray quartzyte (*d*); 800 feet (*e*) of buff and reddish quartzyte with some slate. The quartzite has been made the overlying rock in the view of Mr. Wing by an overthrow fold. This quartzyte belt, with the limestone west of it, stops at New Haven River. But, 80 to 100 rods to the west, another belt begins which stretches northward, passing just east of New Haven village (four miles from New Haven River), and finally joins the Red Sandrock of Monkton.

18.



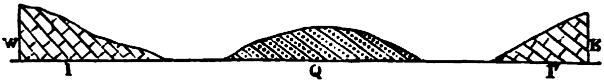
Section south of New Haven River on the southern border of New Haven town.

At a place two and a half miles south of New Haven village, in a field belonging to Mr. J. Brown, a small *Orthoceras* was found over the weathered surface of the dolomite just west of the quartzyte, which was apparently identical in species with those of the locality above-mentioned. The *Orthoceras* is closely like that of Shoreham (figured on page 342), which was found in limestone adjoining the underlying sandrock. The quartzyte at Mr. J. Brown's, two and a half miles north of New Haven village, is 400 to 500 feet thick, dips eastward at an angle of 50° to 60°, and contains "numerous Fucoids and obscure Scolithi."

This locality is one of those I visited with Mr. Wing. The quartzyte is situated between limestone on the east and west, all dipping alike. The dolomitic limestone to the east has a reddish

color seamed with white, somewhat brecciated, and resembles much the red Winooski limestone (Primordial). The quartzyte ridge was nearly half made up of hydromica slate.

19.



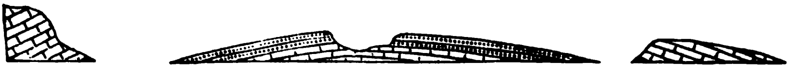
Section near Mr. J. Brown's.

For a mile northeast of the Weybridge Upper Falls, across the railroad, the "striped stratum" is seen in short anticlinals without fossils; but in a fold skirting the western foot of Town Hill, near an old lime-kiln, on the farm of A. Lorraine, three miles southwest of New Haven village, *Rhynchonellæ* were found. The same formation extends on and contains fossils in Brookville, and "in northeastern Middlebury east of Chipman Hill, a little north of Mr. Foot's residence, just east of the road going to Mr. Hammond's."

In the northwestern part of the town of New Haven, one and one-half miles north of New Haven depot, a few rods west of Mr. Charles Mason's residence, the road to Monkton cuts through the western border of a low quartzyte anticlinal, having an eastward and westward dip in the opposite directions. Following the quartzyte northward twenty-five or thirty rods, *Fucoids* and *Scolithi* are found in it. The quartzyte to the west and east dips under heavy beds of "dolomitic siliceous limestone." Farther east there is a thick stratum of white crystalline limestone or marble; next, beds of "sandstone" and concretionary limestone; next, a coarse "sandstone" conglomerate; next, limestone. "Obscure *Orthocerata*, convoluted shells and an *Orthis* were seen," and they appear to be fossils of the "Ophileta beds" or Upper Calciferous. "The limestones end in Monkton not half a mile north of this place," the rock beyond being the Red Sandrock, with its *Scolithi* and *Fucoids*. The Calciferous formation is thus traced to the northern limit of the Eolian limestone.

At my visit to the quartzyte anticlinal just described, I found that there was a small cross-gorge in the quartzyte, showing that the quartzyte had little thickness and that it overlaid a stratum

20.

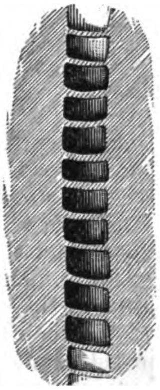


Section of Quartzyte Anticlinal.

of limestone, probably dolomitic, twenty feet in height of which were exposed to view. The beds at this place have only a small dip. The general relations of the beds are shown in the above section.

The quartzyte is in most parts a little slaty in structure, and in limited portions a shining grayish-black slate. In places over it there are areas of sub-concentric conchoidal lamination, looking somewhat as if examples of the flow-and-plunge structure, but more probably a result of concretionary consolidation. To the latter cause I attributed some forms that looked exceedingly like casts of a *Pleurotomaria* and a *Murchisonia*, and of a valve of *Orthis lynx*. Others of these imitative forms over the surface were semi-cylindrical and chambered, as if worn casts of long crinoidal stems; yet having the chambers too large and irregular for any known crinoidal forms. A portion of one of them is here figured natural size; its total length was over ten inches. These simulations of Crinoids may also be due to a concentric structure in the slaty portion of the rock; yet how, it is not easy to understand.

21.



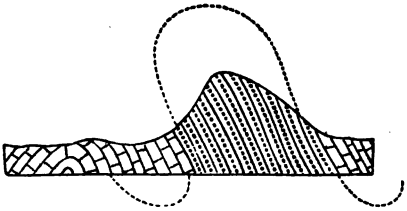
7. *Eastern portion of the Eolian Limestone belt, and the Quartzyte adjoining.*

In this eastern portion of the Eolian limestone, constituting one-fourth to one-third of the whole breadth, no fossils have been found. The more crystalline character of the rock accounts for the absence of fossils. Conclusions as to its age and that of the quartzyte have to be based on other considerations. This evidence of intenser metamorphism on going eastward is apparent beyond the limits of the limestone region, to and beyond the Green Mountain axis.

The interstratification of the quartzyte and Eolian limestone is illustrated in the section given on page 340, in which two bands of dolomite are included between belts of the quartzyte.

In July, 1875, Mr. Wing made, along with Professor Seely, a special examination of the quartzyte mountain called the "Hogback," forming the northern terminus of the Vermont Quartzyte range, and lying near the western foot of the Green Mountains. At the north end of the Hogback a low hill, situated north of the road to Starksboro, is of hard grayish quartzyte, while the main range south is brownish and distinctly stratified, with the dip 70° to 75° to the eastward. North of this low quartzyte hill, the quartzyte extends on northward in narrow masses, and is directly overlaid on the northeast by dolomite and bounded by the same dolomite around the whole northern end. The dolomite on the west was not seen in immediate contact with the quartzyte; but at the nearest point, "some rods distant," it seemed to dip east at a high angle, while a few rods to the west it had a decided westward dip. On the *east* side of the quartzyte at this northern end of the range, and also south to Starksboro, there is another north-and-south range of limestone (dolomite), having an eastward dip conformable to the quartzyte (as represented also in the Vermont Report, p. 346). The figure here given (copied from Mr. Wing's note book) gives his view of the stratification.

22.



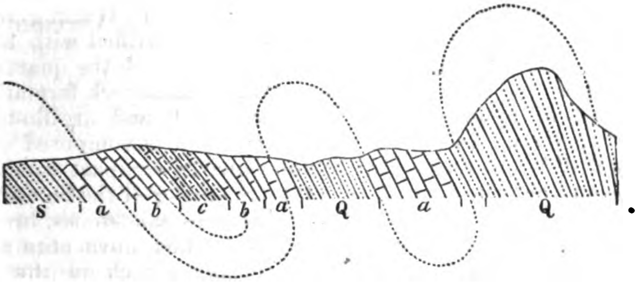
Mr. Wing's section through Hogback.

At Starksboro, *east* of the dolomite, there is a quartzyte ridge which "for a height of 3,000 feet seemed to be an immense flag-stone quarry; the rock is quarried for flagging farther north. It may be called brown quartzyte; it is within the 'Talcose Conglomerate' area of the Vermont Geological Report." The layers are nearly vertical, having a very high eastward dip, conformable with the dolomite and with the quartzyte lying west of the dolomite. The whole valley between the two ranges of quartzyte,—a nearly level strip of country "embracing two or three villages, excellent farms and farm-houses,"—seems to have been made by erosion, the dolomitic and slaty strata having been worn away faster than the quartzyte of Hogback on the west and the Flag-stone ridge on the east. The only fossils of the quartzyte are the *Scolithi* and *Fucoids* observed elsewhere, and these are the same with those of the Red Sand-rock.

The conclusion given in the notes of this excursion in 1875 is,—that "all the rocks in Bristol north and east of Mr. Oaks's residence (on the road next west of Bristol village), all in Monkton and in Starksboro, are older than the Calciferous; the dolomites belong to the Red Sandrock series, or that of the quartzyte, and in some places appear to be 400 to 500 feet thick; and they overlie the quartzyte, being beneath because of an overturn anticlinal." These dolomites here referred to the Red Sandrock series are those called "Subcrystalline limestone" on page 343, which contain the Calciferous *Orthoceras* at Mutton Hill and are there referred to the Lower Calciferous. The following section (from the letter of 1872,) represents the rocks between the Red Sand-rock west of New Haven (see map) and the quartzyte at the village of Bristol, and Mr. Wing's view as to the folds. *a*, The Red Sand-rock dolomite or "Subcrystalline limestone;" *b*, The "Ophileta beds" or Calciferous; *c*, The "Conglomerate" or "Trilobite bed" or "siliceous limestone greatly resembling it," underlying to the south on the strike, "Rhynchonella beds" containing fossils;

Q, quartzyte. Adjoining the Red Sandrock on the west is No. 2 of the section on page 343, a "dolomitic sandstone."

23.

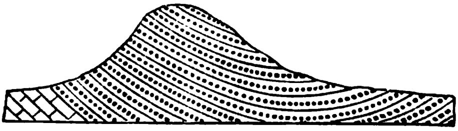


Mr. Wing's section from the Red Sand-rock west of New Haven to the Quartzyte at Bristol village.

In the excursion with Mr. Wing we passed along by the western foot of the Hogback range, north of the village of Bristol. At one point the limestone stratum was seen to form the lower part of the quartzyte bluff, and to dip beneath the quartzyte at a small angle, as if actually an underlying stratum. Mr. Wing spoke of this limestone at the time as part of the Primordial or Red Sand-rock series.

A section of Hogback in the Vermont Geological Report, taken along a line south of the region examined by Mr. Wing, between Bristol and Lincoln, makes the limestone at the *west* base of Hogback dip eastward 45° or so beneath the quartzyte. To the eastward of Hogback along this section no limestone is represented in the figure; but the Report says (p. 346): "in the valley of the north branch of New Haven River, passing up to Starksboro, there are ledges of limestone occasionally seen, interstratified with the quartz rock, nearly as far as Starksboro village; and there is reason to believe that it may extend to meet a narrow belt of limestone running south from Hinesburgh."

24.



Section of Hogback, from Vermont Report.

In my examination of the limestone and quartzyte ridge northeast of Rutland, I found that the dip in both was eastward; but the nearest outcrops of the two were too remote to make it sure that they were conformable. They are conformable according to the section through Rutland and Mendon given in the Vermont Geological Report. The quartzyte in Vermont is in many places interstratified with, and replaced by, hydromica slate (sometimes chloritic), or a hydromicaceous quartzyte or conglomerate—a fact dwelt upon in the Vermont Geological Report, which says as follows, when describing sections across the eastern quartzyte range. In Sunderland the quartz-formation includes, with quartzyte, talcose schist [that is, hydromica slate] (p. 614). In Wallingford the quartzyte and quartz conglomerate are interstratified with talcose schist (p. 627). "Talcose schist is associated with the quartz-rock of Mendon" (p. 634). In Goshen "the quartz rock formation is composed of hyaline quartz, talcose schist, and argillo-talcose schist" (p. 640). In Ripton "the quartz-rock is composed of ten bands of different rocks, viz: hyaline quartz, compact sandstone, talcose and chlorite schist" (p. 645). Speaking of the belt of "talcose conglomerate" it says that it includes sandstones, breccias, quartzyte, coarse conglomerates, talcose schist, novaculite schist, and "talcose schist is the most common rock in the belt" (pp. 386, 387).

I have examined this association of hydromica slate and quartzyte in the quartzyte ridge northeast of Rutland (the ridge making the western boundary of the town of Mendon). Having on my second visit struck the ridge at a different point from that examined on my first visit, I was perplexed by finding hydromica slate in place of true quartzyte; but afterward reached an explanation on observing the gradations of one rock into the other. The Geological Chart of the Vermont Report does not generally represent this interstratification of the quartz and hydromica slate, as the Report observes, because the details were not separately made out owing to the intimate relations of the two. It is shown, however, in Section VIII, where, near Ripton, occurs the remark "Quartz rock interstratified with talcose schist;" and bands of color in the colored section represent the fact.

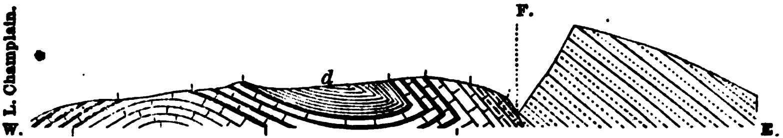
8. "*Great Fault of Western Vermont.*"

Snake Mountain is a north-and-south ridge of Red Sand-rock several miles long, situated to the west of Middlebury, within seven miles of Lake Champlain. It has a steep western face, and gradual eastern slopes—the former across the stratification, and the latter nearly conforming with it. This western side is the course of a great fault.

The rock of Snake Mountain east of the fault is the Red Sand-rock of the Vermont Report, and this continues to be the surface rock eastward to Otter Creek. At the southern extremity of the mountain, in Bridport, west of the mountain, there are the successive Lower Silurian formations, but in an inverted position. The following section gives the order and position of the beds observed at this place.

The first and uppermost rock west of the fault containing fossils is the Chazy; below this comes the Trenton, and next the Hudson River, so that the Chazy and Trenton have been folded back for two or three miles upon the slate. This arrangement in the main prevails along the west front of Snake and Buck Mountains to near Vergennes.

25.



Mr. Wing's section in Bridport, across south end of Snake Mountain.

"Along the highest part of Snake Mountain no slate or limestone is seen at all. At the north end of the mountain the Red Sand-rock has been lifted until it is 700 feet above the level of the Hudson River slates to the west, while at the south end, four or five miles distant, it is much less elevated. Around its northwest end, only the Hudson River slate is seen. Then the Chazy comes in behind the Trenton, and both are folded over on the slate. The Chazy, Trenton, and the Hudson River slate disappear in the same order fàrther south. The Red Sand-rock (Potsdam) appears to have been pushed up and thrust west over these other formations; and so far over, opposite the highest part of the mountain, as to conceal first the Chazy, the Trenton and the Hudson River beds; then, farther north, leaving the Hudson River beds, Trenton and Chazy, along the lower parts of the mountain."

The Chazy beds on the west of the fault afford large *Maclureæ*, one or two species of *Orthoceras*, an *Orthis;* the Black River limestone, *Columnaria alveolata* in great masses, besides other species; the Trenton, *Trinucleus concentricus*, and various other fossils, and the Hudson River slate its characteristic species.

This fault continues south through Bridport, Eastern Shoreham and Orwell to Orwell village and beyond, "but with some irregularity of direction, it following neither a meridian nor the line of a belt or fold."

"Two or three miles south, half a mile west of the village of Shoreham, and south by Sisson's Hill and Barnum's Hill, in the south of Shoreham, the Potsdam proper is folded over on to the Hudson River slate." "Six miles south, 1½ miles west of the valley of Orwell, at Chittenden's Mills, in a deep gorge made by the stream, the Chazy, holding large *Maclureæ*, is seen folded over the Hudson River slate, etc." Mutton Hill adjoins the fault. Again in Waltham, eight or ten miles north of Bridport, the Red Sand-rock is brought up against the Trenton.

Prof. Emmons describes the fault at Snake Mountain and gives a section in his American Geology (vol. I, Part 2, p. 87, 1855); but his section seems to have been taken north of the point described by Mr. Wing; the place is not stated. It makes the formations to the west of the fault lie in regular instead of inverted order. Professor Emmons supposed the rock of Snake Mountain, raised by the faulting, to belong to his Taconic System and therefore pre-Silurian. Prof. Hitchcock, in the Vermont Geological Report, gives a section which represents the mountain *without the fault*.

9. *Conclusions of Mr. Wing as to the Geology of the part of Central and Southern Vermont investigated by him.*

1. The hydromica slates, clay slates, Eolian limestone and quartzyte, with the so-called talcose conglomerate on the east, are all of Lower Silurian age, and conformable in superposition.
2. The Eolian limestone is not Taconic, as made by Prof. Emmons; nor of some one formation, as implied in statements in the Vermont Report and in the name it gave it; nor of the Quebec group, as inferred by Logan; it includes Lower Silurian limestones of various periods, the Upper Potsdam or Lower Calciferous, Calciferous, Quebec, Chazy, Black River, and Trenton.
3. The Red Sand-rock on the west of the Eolian limestone—admitted to be Potsdam or Primordial in age—and the Quartzyte on the east which often rises into mountain ridges, are of the same formation, and come nearly or quite together in Monkton, on the northern limits of the limestone area.
4. These rocks—the Red Sand-rock and Quartzyte—are the western and eastern borders of a great abraded synclinal, the axis of which in its northern part has a slight northward rise (or southward dip), the sides there coming together; and which also has both the eastern and western sides of the fold eastwardly inclined, the dip of the beds being generally eastward. Between its borders there are, in some parts, subordinate longitudinal abraded anticlinals and synclinals.
5. The slates of the "great central belt" are of the age of the Hudson River slates (or that of the Cincinnati group), for the reasons stated on page 345—which are briefly these: (1) the slate-belt is bordered in several places on both the east and west sides by limestone affording Trenton fossils (*Trinucleus*, etc.), and no where else have Trenton fossils been found in the Eolian limestone; (2) there are also narrow north-and-south outcrops of limestones containing Trenton fossils over the interior of the slate-belt, as if brought up from beneath by anticlinals; (3) the slate-belt is plainly underlaid by the limestone at its north end; (4) in Whiting the Trenton limestone of the Sudbury area has a direct connection, across the slate area, with the limestone of Otter Creek valley, east of the belt, which also is Trenton in age—the slate being interrupted "for forty or fifty rods."

The Trenton limestone has been identified west of or within the "central slate-belt," at localities but a few miles apart, in all the towns north of Castleton (the most southern on the map illustrating this paper, p. 335), including, in succession, Hubbardton, Sudbury, Whiting, Shoreham, Cornwall, Weybridge; and east of the slate-belt, in Leicester, Eastern Cornwall and Middlebury. The Chazy limestone adjoins the "central slate-belt" in West Rutland.

6. The several Lower Silurian limestone formations lie in north-and-south belts, with the lowest—the Potsdam and Calciferous—nearest to the Red Sand-rock, or to the Quartzyte, and the upper—the Trenton or Chazy—nearest to the "central slate-belt." This view is presented in the section from East Shoreham to East Liecester on p. 340.

This is confirmed as regards the Trenton limestone, "Sparry limestone," by the list of its localities just mentioned. The Chazy ("Rhynchonella beds") so well represented by fossils at West Rutland, has afforded fossils also in Leicester, East Cornwall, Middlebury, and the same fossils have been found on the east, as on the west, of the "central slate-belt;" while the "striped stratum," which is a marked feature of the Chazy,—"a way-mark by which the rock can be recognized without its fossils," occurs also in Middlebury, in the western part of Brandon by the Burgess Field farm and along the quarries of this part of the town, in the western part of Pittsford, and in Northern Salisbury; and "doubtless it reaches the marble quarries of West Rutland, and continues south through Tinmouth and the whole State; and in this formation is embraced the Birdseye and Black River limestones." "On Crown Point, Lake Champlain, these 'striped beds' are largely developed at the old Forts, and are perhaps 100 yards beneath the Black River limestone—whether in the Chazy or Birdseye is not known. There is a stratum of seemingly pure sandstone, resembling the Potsdam, overlying them at Crown Point. These facts may help to solve the age of the same 'striped beds' in Addison County."

The groups affording the lowest Calciferous fossils on the west of the "central slate-belt" occur next to sandstones of the Red Sandstone formation; and also at two localities north of Middlebury, adjoining beds of quartzyte, or where the limestone and quartzyte come together. The "Ophileta beds," or those referred to the Upper Calciferous, come next, being more remote from the sandstone or quartzyte, as found to be true in Shoreham, Western Cornwall, Weybridge, Middlebury and New Haven.

The beds occur, with their fossils, in Salisbury, Leicester and Brandon.

The eastern range of limestone, or that forming the eastern margin of the great Eolian belt, a mile in width in many places but narrower to the north, is concluded to be Calciferous or Upper Potsdam, because it adjoins the quartzyte, and is dolomitic, the limestone nearest to the outcrops of quartzyte in Northern Middlebury and New Haven being proved by its *Orthocerata* to be—like that nearest the Red Sand-rock to the west of Shoreham—of Calciferous age, if not Upper Potsdam.

The localities affording the Calciferous fossils (Ophileta beds) in Salisbury, Leicester and Brandon lie a little to the west of the great marble formation; and this marble formation is considered the equivalent of the western "Subcrystalline limestone" just above the fucoidal sandstones or Upper Potsdam. The dolomites farther east belong to the Upper Red Sand-rock series, or else the bottom of the Calciferous, as has been elsewhere stated.

The later formations extend less far north than the older because of the inclined axis of the great abraded synclinal: "the Hudson River slates (those of the "central slate-belt") reaching central Weybridge; the Trenton, about a mile farther; the Rhynchonella beds five or six miles farther north; and finally these disappear, owing to the rising into view of the Red Sand-rock."

7. The quartzyte of the eastern range, with that also of the local belts in the Eolian limestone area, is regarded as Potsdam (or Primordial) in age, because it contains in many places *Scolithi* (worm-burrows) and *Fucoids* like those found in the Potsdam sandstone; because also it adjoins Calciferous limestone beds at the localities just mentioned in North Middlebury and New Haven; and because it joins the Red Sand-rock in Monkton, and one rock has in many places the character of the other, although not commonly alike in color, and showing differences explainable on the ground of the greater metamorphism of the quartzyte. "In Monkton, the Red Sand-rock and the Quartzyte meet in a succession of short anticlinals, thus cutting off to the north the great trough or synclinal;" and "the Red Sand-rock absolutely overlies the beds of Red Sand-rock in one anticlinal and the quartzyte in another anticlinal, and both hold *Scolithus linearis.*

8. The quartzyte belt of Rutland Center (just north of Rutland), with the associated slate, extends north by Sutherland Falls nearly to Forestdale, and it runs south of Rutland Center into Clarendon and Tinmouth. It lies throughout within the Eolian limestone area. But it is seen on the map that the area is on the line of strike of the quartzyte-range north of Pittsford. This quartzyte is regarded as Potsdam; and the limestone which lies directly to the west of it (half way from Rutland to the West Rutland valley) is supposed to be possibly the "Ophileta beds" or Upper Calciferous, and the "Conglomerate" or Quebec

group. "But this narrow valley is a very disturbed region, and the limestone seems to be greatly compressed between the quartzyte belt on the east and the slate belt on the west (separating it from West Rutland valley)." "The region was studied farther south in the valley as well as to the north, to ascertain what rocks occurred, and the conclusion was that nearly all the formations found in other places here occur; that is, the older on the east against the quartzyte (No. 1), and then the others in succession, with the Trenton against the slate bounding the limestone on the west, while the slate is No. 8 or the Hudson River slate." No fossils were found in it.

10. *Historical Note.*

The preceding notes have been taken chiefly from the letter from Mr. Wing to me dated August 9, 1872. They show that his view, that there are Hudson River slates in the Eolian limestone region, antedates my own; for my paper on the subject was not published until 1873, and there had been no communication between us before then on the subject, or on any subject. Moreover, my own views as to the age of the Berkshire rocks were based chiefly, as I stated, on Mr. Wing's discoveries in Vermont. I cite the following from a letter to me, of May 8, 1875, written soon after he had first seen my paper on the subject—a letter never, however, received by me until his papers were recently put into my hands. It shows that his conclusions date as far back as 1866.

"When, in 1866, the *Trinucleus concentricus* and other Trenton fossils were found first in Sudbury, underlying on the west side the great central mass of slate running south from Weybridge through the State, embracing the "Talcoid schists" capping Dorset and Manchester Mountains, Mount Anthony in Bennington, and also Graylock in Massachusetts, I reached the conclusion at once that all these slates in Southwestern Vermont and Southwestern New England were neither of the Quebec group, nor Taconic, but of the age of the Hudson River slate. In the progress of my investigations, I assumed, and I often expressed in correspondence with Mr. Billings, that the 'Eolian limestone' of the Vermont Geological Report embraced not only the Trenton and Hudson River beds, but all the formations of the Lower Silurian as well, and even limestones and dolomites of the Red Sand-rock series. I was wrong at first in assuming that these same slates overlying the Trenton and Chazy limestones along this central belt extended also west to the Hudson River and were all of the same age. For the Primordial fossils recently collected at Bald Mountain, Washington Co., and east of Troy, New York (both of which places I have visited), have modified my view as to the western extent of the Hudson River slates. But they have not weakened my belief in their existence in Southwestern Vermont and New England."

From the preceding account of Mr. Wing's discoveries it is evident that he performed well the task he laid down for himself in 1865—the determination of the age of the Eolian limestone. Knowing that fossils were the only sure criterion of geological age, he searched, and he found them, and thus reached sure conclusions. For the western portion of the Eolian limestone and more than half the eastern (that of Otter Creek Valley), the special geological age was thus determined, and the several Lower Silurian formations identified. He further made a right use of the facts, when, in view of the Trenton and Chazy age of the fossils in limestone along the borders of and within the "central slate-belt," and the observation that the beds more remote are successively older—he deduced that the slates were younger than the limestones holding the Trenton fossils, and therefore, in all probability, of the Hudson River (or Cincinnati) group, and that they lay in a synclinal with Trenton and older limestones beneath and on either side.

The more highly metamorphic condition of the limestones making the eastern border of the Eolian limestone prevented his giving to the geology of this part of the region the same positive basis from fossils which he had obtained for the rest.

The Quartzyte also proved almost barren, yielding him only *Scolithi* and *Fucoids*, neither of which serve to fix positively the age of the beds. His argument with respect to it from the well-defined Calciferous fossils found adjoining quartzyte at three different localities on the west and north is however a strong one, and seems to set the question at rest for those outcrops. The Vermont Geological Report states that the eastern Quartzyte range, near Rockville in Starksboro, has afforded a *Lingula*—the specimen containing "scores of fossils but none very distinct"—which Prof. James Hall "regards as a new species related to one in the Medina sandstone," and as evidence "though unsatisfactory" that the quartzyte is of the age of the Medina. From the same Quartzyte range farther south, in the vicinity of Lake Dunmore, Prof. C. B. Adams, as it states, found a shell near a *Modiolopsis* in form; also a tapering shell looking like an *Orthoceras*. Yet the determinations of all these fossils are admitted to be doubtful, and the question of age is still an open one.

One of the most important points established by Mr. Wing is the conformability of the Lower Silurian formations throughout the region. From the Red Sand-rock, or Primordial, upward they make one consecutive series, and all are involved, as Mr. Wing urges, in one system of synclinals and anticlinals. The quartzyte, hydromica slates, and limestones, associated on the eastern border of the region, and the great bands of limestone, hydromica slate and clay slate (or roofing slate), with some quartzyte, making the center and western portion, are of one system, and took, together, their present positions. The great fault which made Snake Mountain was simply one of the breaks and displacements attending the mountain-making movement, as shown years since by

Logan. The observations of Mr. Wing afford nothing to sustain the view that there was an epoch of disturbance in the region at the close of the Primordial or Cambrian period, but, on the contrary, they prove that the rocks went on forming in regular succession nearly or quite to the close of the Lower Silurian; and that then followed, as Mr. Wing concludes, the epoch of upturning and metamorphism. The making of the Green Mountains has for many years been referred by some geologists to this epoch, on the basis of the fossils in the limestones of Vermont. These fuller developments leave no doubt that this view is right, at least so far as the Eolian limestone of Vermont and the associated schists and quartzyte are concerned.

In another number of this Journal I will close this subject by stating the bearing of the Vermont facts on the geology of Berkshire.

ART. XLIV.—*On Barite crystals from the Last Chance Mine, Morgan County, Missouri; and on Göthite from Adair County, Missouri;* by G. C. BROADHEAD.

1. *Barite from Morgan County, Missouri.*

THE rocks of the barite locality in Morgan County, Missouri, are of the age of the Second Magnesian Limestone. A shaft has been sunk in a spring through masses of tumbled rock displaying what seemed, in Missouri miners' parlance, to be a "circle" of about twenty feet diameter. This "circle" was found to be filled with fractured masses of limestone, sandstone and clay for forty feet in depth, or to the bottom of the shaft when I visited it. These masses of rock were often found studded over with beautiful crystals of barite. The galenite was also often covered with such crystals. In some cases a thin coating of transparent barite covered the rock to which the crystals adhered, but they were often seen loosely adhering to the naked rock.

The form of these crystals is different from any heretofore found in Missouri. They are elongated into prismatic forms ($\frac{1}{2}$-$\bar{\imath}$) in the direction of the macrodiagonal axis and are attached to the rock by one of its extremities. The development of the basal plane gives them a flattened appearance. The free extremity of the crystals is gradually sharpened off to a thin edge through the presence of very low macrodome. This is so irregularly developed, however, as not to admit of trustworthy measurements, but seems to have the symbol $\frac{1}{8}$-$\bar{\imath}$. The central portion of all the crystals toward the attached extremity is perfectly transparent. This clear portion has a rhombic form corresponding to the fundamental (cleavage) prism, and is very sharply defined, the remainder of the crystals being of an opaque milky white.

There being a spring of water in the mine. the water may be sometimes charged with an excess of mineral solutions. The lead has probably been deposited from an aqueous solution and the barite from similar and more recent solutions. The waters also seem to have subsequently held iron oxide in solution as some of the crystals of barite are coated with it.

A crystal in my possession from the Cordray mines, but probably from same mine as the above, possesses similar characteristics. It is of rhombic form, about two inches long and a half inch thick; the edges are bevelled by the plains $\frac{1}{2}$-$\bar{i}$ which gave on measurement the angle 77° 40′. It has a border a half inch wide of white opaque barite, the outer angle sharp, inner angle truncated, and the remainder is clear mineral, which corresponds in shape to the cleavage prism; the direction of the cleavage is also indicated by cracks across the crystal. The white portion of this crystal would seem to indicate alteration, but that can hardly be the cause of the similar appearance of the crystals from the Last Chance mine.

2. *On the Göthite from Adair County, Missouri.*

The Coal measures, it is well known, often contain, within the thicker shale beds, interstratified beds of clay ironstone, sometimes in connected layers, at other times in concretionary masses, occurring along a marked horizon. These concretions are often reticulated by calcite veins, one system in concentric lines, the other crossing them; they are generally termed septaria.

In 1873, while examining the structure of the formations on Chariton River, Adair County, Missouri, I broke open a number of the concretionary masses which were reticulated by veins of calcite from a quarter to half an inch wide, occasionally widening into small cavities one-eighth to one-half an inch high, lined with calcite crystals reposing on the more compact calcite of the vein. Upon and sometimes interpenetrating these crystals are small slender acicular crystals of black göthite, generally not more than an eighth of an inch, but sometimes as much as three-fourths of an inch, in length. The göthite is generally aggregated in bundles at the base of the calcite from which they radiate. Sometimes a single crystal will shoot directly through a calcite crystal. Sometimes also, a single point of a quartz crystal will be seen penetrated in various directions by the göthite. The calcite, often, has its angles bevelled or rounded, and they were sometimes colored red on the surface as was also a little of the göthite. Minute velvety balls of göthite not larger than the one-thirty-second of an inch were also found reposing on the calcite.

Pleasant Hill, Mo., March, 1877.

ART. XLV.—*Estimation of Chromium and Aluminium in Steel and Iron;* by ANDREW A. BLAIR.

HAVING had occasion, several years since, to examine a number of samples of so-called "Chrome-steel," for the percentage of chromium, I began by searching for this element in the residue left after acting on the steel with dilute HCl, as, in the case of cast-iron, this plan is recommended.* Failing to find it here, except in very small amounts, there seemed to remain two methods of procedure: the first being to fuse the sample with Na_2CO_3 and KNO_3, either directly† or after oxidizing‡ by HNO_3 and evaporating to dryness; the second, to treat the solution of the steel containing the iron as a ferric salt, with KHO, Na_2CO_3 or Na_2CO_3, and $NaC_2H_3O_2$, in excess, and in this alkaline or acetic acid solution oxidizing the Cr_2O_3 to CrO_3, by means of Br, Cl, PbO_2 or $KMnO_4$, which combines with the alkali as a soluble alkaline chromate, while in the cold or upon boiling, the iron is precipitated as hydrated sesquioxide or basic acetate.§ While both of these general methods will undoubtedly give good results, when large amounts of chromium are present, so that small amounts of the original substance can be operated upon, they present many objectionable features when the percentage of chromium is small, and the amount of steel or iron that must necessarily be used is correspondingly large. The principal objections are, in the first method, loss by spirting during fusion, and in both, the difficulty of washing the voluminous precipitate of iron free from alkaline chromate. A third general method, viz: separating the Cr_2O_3 from the Fe_2O_3 by means of $C_4H_6O_6$, NH_4HO, and NH_4HS, exactly as in the separation of Al_2O_3 and Fe_2O_3, might be added, but the difficulty of washing such a mass of ferrous sulphide seemed quite impracticable, and the method was not even attempted.

By means of barium carbonate, Cr_2O_3 may be perfectly precipitated,‖ and thus separated from the great mass of the iron, which in a hydrochloric acid solution of the steel would exist as a ferrous salt. Following out this plan the result was the following method.

Five grams of borings or drillings are weighed out into a flask of about one-half liter capacity, twenty cubic centimeters strong HCl diluted with three to four times its volume of water poured in, and the flask closed with a rubber stopper, provided with a valve, such as is used in dissolving iron wire in volumetric analysis. Heat is applied as required, and, when all the steel is dissolved, a solid stopper is quickly substituted for the one with the valve, and the flask and contents cooled. When cold, the solution is diluted with cold water until the flask is about three-fourths full, and a slight excess of $BaCO_3$ added with constant agitation. The $BaCO_3$ should be free from $BaSO_4$, as it obscures the reaction, and too great an excess should be avoided.* The flask should be thoroughly shaken several times, loosening the stopper occasionally to allow the CO_2 to escape, and allowed to stand over night. It is then filtered as rapidly as possible, the flask rinsed out several times with cold water, and the precipitate on the filter (consisting of all the Cr_2O_3, the residue from the steel insoluble in dilute HCl, some Fe_2O_3 and the excess of $BaCO_3$) washed well with cold water. The filter is then punched and the precipitate washed into a small clean beaker, the portion adhering to the sides of the flask dissolved in HCl, which is poured on the filter and the filter cleared from any Fe_2O_3 by HCl and thorough washing with hot water.† If sufficient HCl has not been used in clearing out flask and washing filter, enough is now added to dissolve all the Fe_2O_3, Cr_2O_3, $BaCO_3$ in the beaker, the solution diluted, boiled and the Fe_2O_3 and Cr_2O_3 precipitated by NH_4HO, the boiling being continued until all smell of NH_4HO has disappeared. This precipitate is filtered and washed thoroughly with hot water to get rid of all $BaCl_2$; dried and transferred to a platinum crucible, carefully separating the filter, which is ignited and the ashes added to the precipitate (which should not be heated). A mixture of three grams Na_2CO_3 and one-half gram KNO_3 is now added, and the whole fused carefully, the heat being raised gradually until all the KNO_3 is decomposed. After cooling, the fused mass is treated with hot water, and the soluble portion containing the Cr as alkaline chromate, with the excess of the alkalies, separated from the Fe_2O_3 by filtration, the precipitate and filter being thoroughly washed with hot water. The filtrate is acidulated with HCl, and evaporated to dryness with a little alcohol; when thoroughly dry, the Cr_2O_3 is dissolved in HCl, diluted and filtered from silica, the Cr_2O_3 precipitated by NH_4HO, filtered with the usual precautions, ignited and weighed as Cr_2O_3,* calculated to Cr by the factor 0·6853. Atomic weight of Cr 52·2.

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* Wöhler's Mineral Analysis (Nason), p. 204.

† Watts's Dict. of Chemistry, vol. iii, p. 374.

‡ Rose's Chim. Anal. Quant., (French ed., 1862), p. 987.

§ Crookes's Select Methods, p. 127. W. Gibbs in Am. Journ. Science (II), xxxix, 58. Chancel, Compt. Rendus, xliii, 927.

‖ Rose, Chim. Anal. Quant., p. 513. Fresenius, Quant. Chem. Anal., vi ed., English, p. 379.

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* It is almost impossible to buy $BaCO_3$ free from $BaSO_4$, the very best brands containing from 5–30 p. c. of $BaSO_4$. I prepare my own by dissolving $BaCl_2$ in water, filtering, adding large excess of NH_4HO and passing CO_2 into solution, until all the barium is precipitated as $BaCO_3$, washing thoroughly, drying, and grinding in water to the consistency of cream.

† If it is desired to determine the chromium soluble in dilute HCl alone, or separately from that which remains in the insoluble residue, the filter should not be punched, but the Fe_2O_3, Cr_2O_3, and $BaCO_3$, dissolved on the filter, in dilute HCl, and a separate determination made of the Cr in the insoluble residue (which remains on the filter) by burning the filter and fusing with Na_2CO_3 and KNO_3.

The only impurity this precipitate can contain is a little Al_2O_3, partly from the Al in the steel, and partly as an impurity in the Na_2CO_3 and KNO_3. The best method for separating this impurity, is to add to the solution of alkaline chromate obtained above (after fusion and filtration from Fe_2O_3) an excess of $KClO_3$, then a slight excess of HCl, and evaporate to syrupy consistency on the water bath, adding a little $KClO_3$ from time to time, so that there may always be an excess to decompose any HCl. Redissolve in water, add a slight excess of $(NH_4)_2CO_3$, and boil off all smell of the latter, filter, wash with hot water, add to solution an excess of HCl and, after the greater part of the $KClO_3$ is decomposed, a little alcohol, and precipitate the Cr_2O_3 as before.† In Genth's method (loc. cit.) of evaporating the solution of alkaline chromate nearly to dryness on the water bath, with an excess of $(NH_4)NO_3$, a minute amount of CrO_3 is reduced to Cr_2O_3, and precipitated; it is consequently filtered off with the Al_2O_3, SiO_2, etc., and lost, unless this residue should be treated separately to regain this Cr_2O_3, which very much complicates the process. If in the filtrate so obtained the CrO_3 is precipitated by $HgNO_3$ as Hg_2O, Hg_2CrO_4, some of the chromium salt nearly always passes into solution upon filtering, and can be detected, sometimes in very considerable amounts, in the filtrate. The same thing occurs if this method of precipitation is used, after neutralizing the solution of alkaline chromate (obtained by fusion with Na_2CO_3 and KNO_3, and filtering from the Fe_2O_3) by HNO_3. In all cases I have obtained the most satisfactory results by reducing the CrO_3 to Cr_2O_3, precipitating by NH_4HO, and weighing as Cr_2O_3.

This method for estimating chromium in steel may appear a little tedious, but quite a number can be made at once and only about three to four days is required for a complete estimation. The accuracy is all that can be desired and the delicacy of the method in detecting and estimating very small amounts, greater than that of any method I have used. I think I can safely say that it is delicate to 0·005 per cent of Cr. The amount of Fe_2O_3 usually precipitated by the $BaCO_3$, with the Cr_2O_3 is about 0·05 gram.

For techinal work the method can be very much shortened by fusing the precipitate by $BaCO_3$, with Na_2CO_3 and KNO_3 or

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* For precautions necessary to free Cr_2O_3 from alkaline salts, see Genth in Chem. News, vi, 30. Fres. Chem. Anal. Quant., 387.

† Dexter's method, see Rose, Chim. Anal. Quant., p. 520. Fresenius, Chem. Anal. Quant., p. 372. Pogg. Anal., lxxxix, 142.

$KClO_3$ (when $KClO_3$ is used instead of KNO_3 the precipitate must be thoroughly ground in and incorporated with the flux before fusing) dissolving in water, filtering, and determining the CrO_3 volumetrically. The results obtained in this way are fairly good, but are apt to be a little low.

Aluminium, nearly always exists as such in steel, and may be estimated with great accuracy by proceeding exactly as in the above method for the determination of chromium, until after filtering and washing the precipitate by $BaCO_3$, which is then dissolved on the filter in dilute HCl and the solution allowed to run into a small clean beaker. This solution is diluted, boiled, and the barium precipitated by a slight excess of dilute H_2SO_4; the $BaSO_4$ allowed to settle, filtered, washed, and the filtrate evaporated nearly to dryness to get rid of the excess of acid. This solution is then diluted, and the Fe_2O_3, and Al_2O_3 separated by $C_4H_6O_6$, NH_4HO, and NH_4HS. If the steel contains any chromium it will be with the Al_2O_3, and must be separated by fusing the residue obtained by running to dryness the filtrate from the FeS and igniting with Na_2CO_3, and KNO_3; dissolving in water and, without filtering, adding $KClO_3$ and HCl, as before in the separation of Al_2O_3, and Cr_2O_3. The Al_2O_3 obtained on precipitating by $(NH_4)_2CO_3$ will be contaminated by small amounts of SiO_2, and CaO (from the $C_4H_6O_6$) from which it can be separated by dissolving on the filter in HCl, after washing free from alkaline chromate, into a small clean beaker, running to dryness to render SiO_2 insoluble, dissolving in HCl, filtering, and precipitating the Al_2O_3 by NH_4HO, being careful to boil off all smell of NH_4HO. After filtering and careful washing the precipitate can be dried, ignited, and weighed as Al_2O_3, calculating to aluminium by the factor 0·5331. Atomic weight, 27·4.

The great solubility of the Cr of chromium steel in the most dilute HCl certainly seems to indicate the existence of a true alloy of iron and chromium, and that a large part at least of the chromium exists as such, and not as an oxide or in any intermingled slag. Mr. E. Riley,* at a meeting of the Chemical Society, March 15, 1877, presented some specimens of chromium pig-iron containing from six to seven per cent of Cr. He mentioned the fact, during his remarks, that the Cr had dissolved with the Fe in the course of analysis. The president, Professor Abel, F.R.S., said that he had examined a specimen of the so-called chromium steel, but had found a mere trace of chromium in it. It was possible however, he said, that the chromium exerted a function in the production of the steel, but was eliminated at some stage in the process, so that it did not appear in the finished steel.

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* **Chemical News, No. 904, March 23, 1877.**

In this connection the following analyses may not prove uninteresting, showing as they do that, in some cases at least, the chromium does "appear in the finished steel."

Sulphur,	0·005	per cent.	trace		trace	
Phosphorus,	0·021	"	0·020	per cent.	0·005	per cent.
Silicon,	0·129	"	0·189	"	0·279	"
Total carbon,	0·825	"	0·935	"	1·199	"
Comb. carbon,	0·811	"	0·920	"	1·186	"
Graphitic carbon,	0·014	"	0·015	"	0·013	"
Manganese,	0·245	"	0·062	"	0·039	"
Copper,	0·007	"	0·010	"	0·005	"
Nickel,	trace		0·023	"	0·021	"
Cobalt,	0·016	"	trace		0·018	"
Aluminium,	0·034	"	0·029	"	0·026	"
* Chromium,	0·651	"	0·223	"	0·916	"
Chromium, soluble,	0·615	"	0·212	"	0·899	"
Chromium in residue,	0·021	"	trace		trace	
Slag,	0·320	".				

The determinations of Cr marked * were made by the first method without the separation of Al, and consequently are a little higher than the sum of the "chromium soluble in dilute HCl," and "chromium in residue," which were determined in the portion and by the method taken for estimation of Al.

The "slag" in the first analysis given above, was determined by the "iodine" method and contained by analysis Fe_2O_3 0·110 per cent, Cr_2O_3 0·160 per cent, undetermined 0·50 per cent, total 0·320 per cent.

Laboratory of U. S. Board appointed to test Iron, Steel, etc.
Watertown Arsenal, Mass., April 14, 1877.

ART. XLVI.—*On the Chemical Composition of Triphylite, from Grafton, New Hampshire;* by SAMUEL L. PENFIELD. *Contributions from the Sheffield Laboratory of Yale College.* No. XLVII.

THE rare mineral species, triphylite, is found at Grafton in a granite vein which has been extensively worked for mica. It occurs imbedded in the granite in masses of varying size, and occasionally of fifty or more pounds in weight. The exterior of the masses in some instances shows evidences of the decomposition to which the mineral is peculiarly liable, but a large portion of the material is fresh and unaltered. It has a light blue color, a greasy to resinous luster and a perfect cleavage. Specific gravity =3·52. Analyses of the finely pulverized, pure mineral, dried over sulphuric acid, show the following composition:

	I.	II.
P_2O_5	44·18	43·88
FeO	26·09	26·38
MnO	18·17	18·24
CaO	·89	·99
MgO	·56	·61
Li_2O	8·77	8·81
K_2O	·32	·32
Na_2O	·16	·09
H_2O	1·47	1·47
	100·61	100·79

The phosphoric acid was separated from the iron and manganese by fusion with sodium carbonate, except a small amount retained with the iron, which was separated afterward by means of molybdic acid.

The alkalies were separated from the iron and phosphoric acid by adding a small amount of ferric chloride to a nearly neutral, oxidized solution of the mineral and precipitating the iron and phosphoric acid together by means of barium carbonate. Care was taken to use platinum vessels in conducting the evaporations. The total amount of water was expelled by ignition and determined by absorption in a chloride of calcium tube. Water amounting to 0·50 per cent was driven off at 100° C. These results show the Grafton mineral to be richer in manganese and lithia than that from Bodenmais.

The relative number of atoms calculated from analysis 1 are the following:

P	·622				6·22
Fe	·362	·648			6·48
Mn	·256				
Ca	·016				
Mg	·014				
Li_2	·292	·297	Li	·584	·594
K_2	·003		K	·006	
Na_2	·002		Na	·004	
		·945			

The above gives the ratio of the phosphorus to the bases =·622 : ·945 or 1 : 1·52, which shows the composition of the mineral to be that of a normal phosphate. The ratio of the atoms of the univalent elements to those of the bivalent is ·594 : ·648 = 1 : 1·09 which gives the formula $10\overset{\mathrm{I}}{R}_3PO_4+11\overset{\mathrm{II}}{R}_3P_2O_8$. Rammelsberg* deduces the formula $4\overset{\mathrm{I}}{R}_3PO_4+5\overset{\mathrm{II}}{R}_3P_2O_8$ from the most trustworthy analysis of the Bodenmais mineral, but suggests $\overset{\mathrm{I}}{R}_3PO_4+\overset{\mathrm{II}}{R}_3P_2O_8$ as possibly the true formula. The composition here obtained for the Grafton triphylite renders it almost certain that this is the correct formula of the mineral. This work was conducted in the Sheffield Laboratory under the supervision of Professor O. D. Allen, to whom I wish here to express my thanks.

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* Mineralchemie, 1875, page 307.

ART. XLVII.—*On a new Mode of Manipulating Hydric Sulphide;* by JOSIAH P. COOKE, Jr., Erving Professor of Chemistry and Mineralogy in Harvard College.*

IN chemical laboratories, where instruction in qualitative analysis is given to large numbers on the class system, the use of hydric sulphide gas as a reagent is attended with grave inconveniences. These evils can in great measure be avoided by substituting for the gas a solution of the reagent in water, saturated at the ordinary temperature and pressure of the air; when, as is well known, one volume of water dissolves about 3·4 volumes of the gas (measured at 15° C. and seventy-six centimeters). Such a solution was for a long time used in the laboratory of Harvard College. It was prepared in a long series of two liter bottles connected by glass tubes in the usual way, and the solution was kept in the laboratory in a large tubulated glass flask, from which it was drawn by the students, as occasion required. This solution answers almost every purpose for which the reagent is used in the ordinary course of qualitative analysis, and the few conditions under which it does not give satisfactory results can be easily avoided. Moreover, in ease of application and promptness of effect it has all the advantages of a liquid reagent; and the only inconveniences its use involves is an occasional evaporation of a solution, which the dilution by the reagent may render necessary. Of course a solution of hydric sulphide is liable to oxidation, and soon becomes turbid in contact with the air; but this change can be easily avoided by fitting to the neck of the flask (in which the solution is kept), by means of a rubber stopper, a glass tube dipping under the liquid, and connecting this tube with one of the vents of illuminating gas in the laboratory.

For quantitative work, and for the preparation of chemical products, when considerable quantities of metallic sulphides must be precipitated, a solution of hydric sulphide, saturated under the ordinary pressure of the air, is inconveniently dilute; and two years since we described a simple method by which a solution concentrated under pressure could easily be prepared with the ordinary laboratory appliances. A heavy glass bottle of about four liters' capacity served as a generator, and from this the gas passed through a wash-bottle into two other bottles of the same size and strength as the first. The intermediate bottle was three-fourths filled with water, while the last served simply as a gasholder. The connections were so arranged that the gas, after bubbling up through the water, was delivered at the top of the gasholder; and, by a tube uniting the bottom of the gasholder with the water-pipes of the laboratory, the interior of the apparatus could be submitted to the pressure of a column of water sixty feet high. The gasholder was also provided with an exit tube, which could be closed by a compression cock. The connecting tubes all passed through rubber stoppers which were firmly wired to the necks of the bottles, and the water-bottle was connected with its neighbors by two lengths of stout rubber hose so that the water could be shaken up with the gas without disturbing the rest of the apparatus. In order to saturate the water with hydric sulphide, a charge of ferrous sulphide, sulphuric acid and water sufficient to yield at least three times the amount of gas theoretically required was placed in the generator, and, after the connections were made, the gas was allowed to steam through the apparatus until all the air was displaced. The exit tube of the last bottle was then closed, the water pressure turned on and the water-bottle frequently shaken, until absorption ceased, and the aqueduct water—at first forced by its pressure into the gasholder—was driven back into the pipes. Before dismounting the apparatus, the rubber connectors were all closed by compression cocks, and care was taken to vent the generator gradually. Moreover, the connectors of the water-bottle were so arranged that when the apparatus was dismounted a short piece of rubber hose was left attached to each orifice of the bottle, both of which were closed by compression cocks. To one of these a vent tube was subsequently attached, and by this the solution was drawn off at pleasure, as from a soda-water siphon.

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* From the Proceedings of the American Academy, vol. xii (N. S. iv), p. 113, 1877.

This simple apparatus was constantly used by us for two years, and served an excellent purpose; but it was found that after the glass generators had been charged several times they were liable to burst under the same pressure which at first they had readily sustained. The same accident never happened to the other bottles. But of course, if the pressure is long continued, bottles of glass of the size named, however well made, would be liable to such an accident; and, if the apparatus is to be remounted, it would be better to use a metallic vessel for the generator, and to cover the glass bottles with some kind of netting. The experience with the glass apparatus led us to seek to adapt to the same purpose some one of the various soda-water apparatuses which are greatly used in the United States for the production of effervescing drinks. After examining several of the patterns in the market, we selected for trial the one represented below, which is manufactured by the firm of John Matthews, of New York, at their establishment,—First Avenue, 26th and 27th Streets,—in that city. The apparatus was designed by them for preparing that overcharged aqueous solution of carbonic dioxide, which in the United States is familiarly called soda-water; but with a very slight modification it can be used with equal efficiency for the preparation of a similar solution of hydric sulphide. We have worked out the details of the process, which this new application involves, and publish them with the hope that the apparatus may be found of as great value in other laboratories as in our own. The wood-cuts are taken from the catologue of the firm, who have kindly loaned the blocks for this paper; and we would here express our obligations to them for their great courtesy and liberality during the whole course of our experiments.

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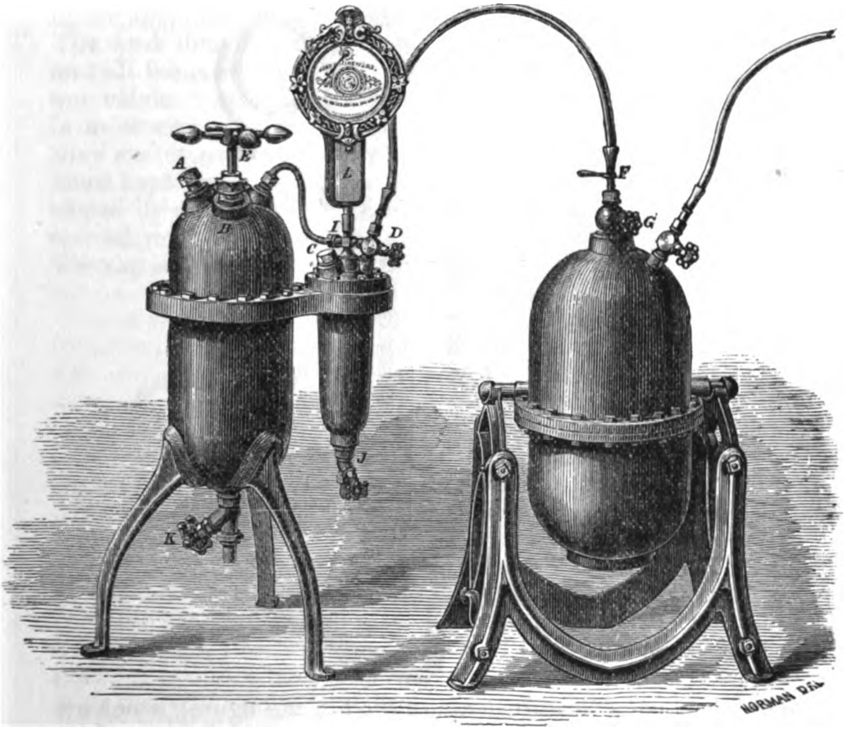

The apparatus consists of two parts, the generator and the fountains; and in Fig. 1 the generator is represented connected by a rubber hose with one of the fountains, of which in practice we use three, connected in a line by similar lengths of rubber hose, like so many Woolf's bottles. In the figure, only the first of the line is represented, which is set on trunnions in a frame, in order to facilitate the agitation of the water and the gas. Only one of these frames, however, is required, to which the other fountains can readily be transferred. A section of the generator is represented in Fig. 2. It is made of cast iron, and in two parts (readily distinguished in the figure), which are firmly bolted together, so as to confine in its place the bell-metal plate M, which separates the upper from the lower chamber. In the lower chamber is placed dilute sulphuric acid, which is poured in through the bung A. In the upper chamber, and resting on the plate, is placed coarsely powdered sulphide of iron, which is put in through the bung B. Through the plate M, and on two lines at right angles to each other. there are cut radial slits, half an inch wide, which are guarded by four iron arms. These arms are attached to the agitator shaft S, and move over the surface of the plate, alternately

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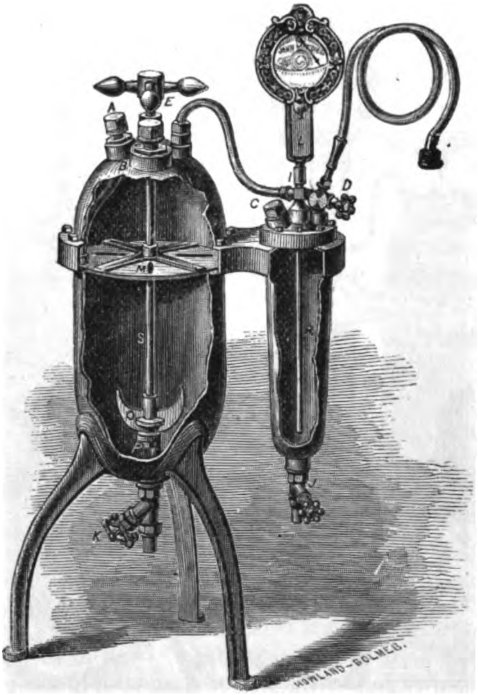

covering and uncovering the slits, when the handle E is turned. To the lower end of the same shaft is fastened the agitator O, which is turned simultaneously with the arms just mentioned. After the apparatus has been charged, it is evident that by turning the handle the sulphide of iron may be sifted down at pleasure into the acid water below; and the handle and arms are so disposed that when the bungs are uncovered by the handles the slits are covered by the arms. From the generator, the gas passes through the washer R, whose relations to the apparatus, as well as that of the pressure gauge, are evident from the figure. The generator is lined with lead, and the rest of the apparatus, including the bell-metal plate M, with pure tin. The lead lining of the generator is seamless and very heavy, and all the cocks are lined with block tin tubing. Of the various valves, bungs, and stuffing boxes indicated in the figure, it is unnecessary to speak in detail. It is sufficient to say that they are of excellent workmanship, and during a year's trial have kept perfectly tight. The charging bung, B, however, is closed by a safety cap of peculiar construction, which deserves special mention, because it insures the safety of the apparatus. The cap is represented by Fig. 3, and a section is given in Fig. 4.

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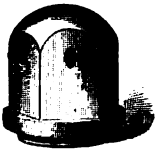

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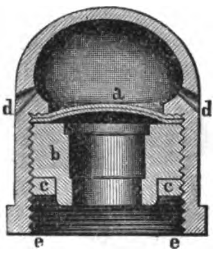

5.

It will be seen by the last that the escape of the compressed gas from the generator through the apertures *d* is only prevented by a thin disk *a*, which is shown in detail by Fig. 5. This disk is made of two thin plates: the lower one, which comes in contact with the acid spray, is of lead, and the upper one of silvered copper, whose thickness is so adjusted that it must be at once ruptured if the pressure in the apparatus should become unduly great.

Although the so-called soda-water fountains—in which the solution of the gas and water is made—have all in general the same simple relation of parts, they are constructed of very different materials and after very different methods. The outside shell may be either of hammered copper or of some form of iron, and this may be lined with tin, enamel, or glass. After having determined by experiment that a solution of hydric sulphide—especially when some carbonic dioxide is added—exerts no action on a surface of metallic tin, except a very slight and superficial staining, we selected as best adapted to our purpose the steel fountains, also manufactured by the firm of John Matthews, Fig. 6. These are made of plates of steel

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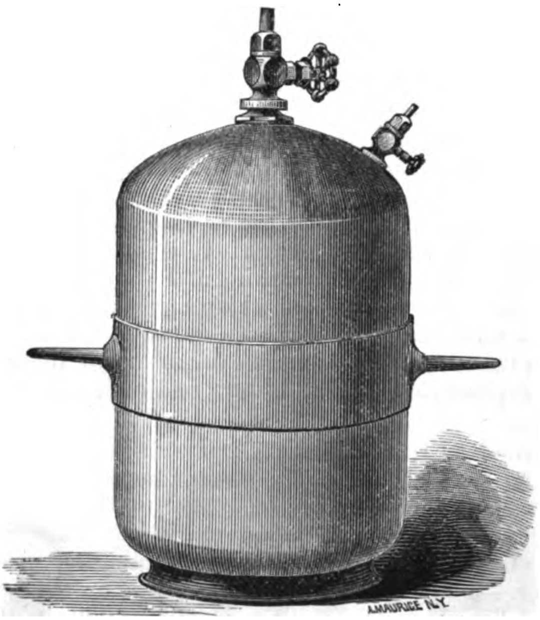
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united in a peculiar way invented by themselves so as to secure with comparative lightness very great strength. They are lined on the inside with sheet tin, and the tin lining forms an independent vessel, which alone is connected with the bungs. The tubes and valve cocks are also either made or lined with tin, so that the solution never comes in contact with any other metal. For making ordinary soda-water, the fountain requires only a single valve, which connects with a tube leading to the bottom of the vessel, and this serves both to charge the fountain and to draw off the solution when made. But since a solution of hydric sulphide is rendered turbid if left in contact with even a small quantity of air, and since a variable amount of free hydrogen is always formed by the action of sulphuric acid on common sulphide of iron, it was necessary for our purpose to add to the ordinary fountain a vent cock as shown in the last figure. This enables us to connect together several fountains after the manner of Woolf's bottles, as already described, and, by passing the current of gas through the whole line, to drive out all the air originally in the apparatus, as well as the free hydrogen subsequently evolved. Moreover, in the preparation of the solution of hydric sulphide, the generator should be much larger relatively to the fountains than in the preparation of soda-water. Thus we use for charging the so-called six-gallon steel fountains, the "Upright Generator," known as No. 40, which has a capacity below the diaphragm of sixty liters. It should be here stated that the fountains are only rated at two-thirds of their total capacity, which is the volume of soda-water which is ordinarily made in them. They should never be more than three-fourths filled with water. But, even with this liberal allowance for gas room, the six-gallon fountains referred to will hold twenty-five liters of water. It may also be stated, although the fact must be evident, that a single large fountain will not give as good results as several small ones of equal capacity; since in expelling the air and free hydrogen, as we have described, there would be a considerable loss of material, if only one fountain were used. Still, in laboratories where the consumption is not great, the loss is not important; and the smallest "Upright Generator," with one six-gallon fountain, will be found to be a perfectly satisfactory apparatus.

Assuming first that the larger apparatus is used, the method of charging is as follows: The large generator is too heavy to be readily moved, and should be placed so that the discharge valve will empty directly into a drain. Water also should be brought to the apparatus by hose,—if possible, both hot and cold water,—not only for convenience in charging, but also in washing. Finally, there ought to be a good flue in the neighborhood, into which the waste gas may be discharged. The apparatus having been thus established, the three fountains—first rinsed out—are filled each with twenty-five liters of distilled water, and the valves having been secured, the fountains are connected with each other and the generator by means of stout rubber hose as already indicated, and the vent valve of the last fountain is connected with the flue by a length of common gas hose. The generator is then charged as follows: The handle is first placed so as to uncover the bungs and cover the slits in the diaphragm. Through the bung A is now poured forty liters of *hot* water, heated to between 70° and 80° C., and then five liters of common oil of vitriol are poured very cautiously into the same bung through a lead funnel with narrow spout provided for the purpose. The acid water will thus be heated nearly to the boiling point, and its capacity of dissolving ferrous sulphate raised to the maximum. Next six kilograms of sulphide of iron—previously sufficiently pulverized to pass through a wire sieve with eight meshes to the inch, and mixed with two kilograms of marble powder—is run through a wide-mouth funnel into the bung B. The bungs having been now all closed, the joints of the apparatus tested, the exit valve D of the generator and all the valves of the fountains opened. a small amount of the powder is sifted down into the acid water by turning the handle not more than a single revolution, always taking care to leave it so that the slits of the diaphragm shall be left covered. The gas is then allowed to stream through the apparatus, and tested as it escapes into the flue, until it burns without explosion, using a small pneumatic trough for that purpose. The air is now nearly expelled, and the escape of gas should be reduced by the last vent valve until the current only supplies a small jet, which may now be attached and lighted with safety, and by the size of this flame the vent may afterwards be regulated. The handles are now slowly turned, and the pressure in the apparatus carried up to about 120 pounds. The valves of the fountains and the valve D of the generator are now all closed, and the two last fountains detached, leaving the first (which is mounted on a frame as represented in Fig. 1) united to the generator as before. This is now rocked for several minutes to and fro, in order to thoroughly agitate the water with the gas. The stop valve G should then be opened, and then the valve D (very gradually), so that the gas may be admitted slowly to the fountain. The valves are then again closed, and the agitation renewed, and the same operation is repeated several times until no more gas is absorbed by the water in the fountain, the pressure in the generator meanwhile being maintained at 120 pounds, by turning the handle. The first fountain is then removed, and the same process repeated with each of the others. At the close of the operation, after all chemical action has ceased, there remains in the generator—both free and dissolved in the liquid residue—a large volume of hydric sulphide gas. This we economize by venting the generator slowly through Woolf's bottles containing aqua ammonia, and thus preparing at the same time ammonic sulphide. It is not unimportant to add that the generator should be emptied before it cools, and the ferrous sulphate has time to crystallize. The discharge valve R should then be removed, and the whole apparatus thoroughly washed out. If the valve becomes clogged, it can generally be cleared by developing pressure in the generator by means of a small charge of ground marble. Otherwise, after the pressure has been relieved, and the upper valves and bungs closed, the discharge valve must be cautiously removed, and an opening forced through the lower bung. Such details are necessary in order that others may profit by our experience; but, lest the details should convey the impression that the apparatus is complicated, and that the process requires skilled labor, it may be stated that in this laboratory the apparatus is entirely in charge of a laboratory servant, and may be managed by any workman of ordinary intelligence. It does not require more than four hours to work over a single charge, and this yields seventy-five liters of hydric sulphide solution under a pressure of 120 pounds. According to our experience, this supply lasts with a class of one hundred students in qualitative analysis about a month. For laboratories where the classes are much smaller than this, we should recommend the smallest size generator, which may be used with a single six-gallon fountain. The smaller apparatus is managed in precisely the same way as the larger, only taking one half the quantity of materials. It is important as before to wash out in the first place all the air, and to maintain a small current of gas through the vent valve of the fountain while the pressure in the apparatus is rising. This of course entails some loss of hydric sulphide; but the chief loss is caused by the venting of the generator, and all this gas may be utilized for the preparation of alkaline sulphides as described above, or this waste gas may be used for washing out the air from a second fountain, and thus preparing it for a subsequent charge.

For dispensing the reagent in our *qualitative* laboratory, we place the fountain in a cupboard and connect it by a block-tin tube with a so-called "draught column," Fig. 7, in the ventilating hood above. From this each student draws the reagent as it is required. In quantitative work we may draw the charged water directly from the fountain into the midst of the solution to be treated, using simply a common rubber hose terminated by a glass tube which dips under the surface of the liquid: the hose is attached to the nipple of a cap which screws on to the valve of the fountain, and by confining two or more disks of linen cloth between the cap and the head of the valve (like washers) we can filter the solution as it flows out. It is more convenient, however, to distribute the reagent to advanced students in the well-known soda-water siphon, Fig. 8. These require no description, but as the simple apparatus used for filling the siphon is not yet a familiar object in chemical laboratories, we give a figure of the apparatus (Fig. 9), taken, like our other cuts, from the catalogue of John Matthews. By

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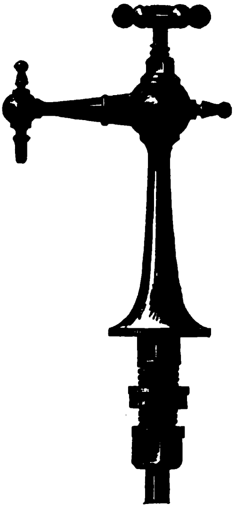

pressing the foot on a pedal shown at the base of the apparatus, the siphon—confined in a cage—is raised, so that its mouth is forced tightly against one opening of a valve of peculiar construction, the second opening of which is united by a block-tin tube to a fountain; while at the same time the handle of the siphon is pressed back. On now pushing the upper lever shown in the cut to the right, the valve of the fountain having been previously opened, a connection is made between the fountain and the siphon; when the charged water rushes into the latter, condensing the air to a fraction of its original volume. If next the same lever is pushed momentarily to the left, the first connection is closed; while a vent is opened, through which the condensed air rushes out into the atmosphere before the gas in solution has time to escape, and then on pushing back the handle a further portion of liquid enters, nearly filling the interior of the bottle. Lastly, on raising the foot, the valve of the siphon shuts at the same time that the

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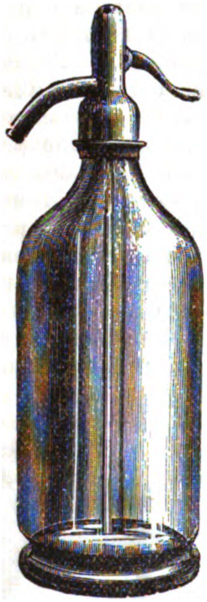

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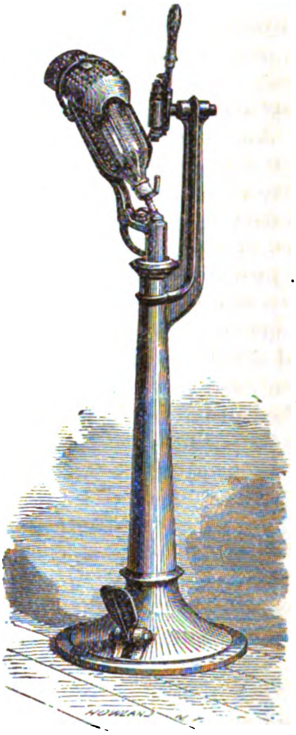

bottle is lowered and released from its cage,—the whole process being the work of a few seconds. At the first filling, there sometimes remains a small amount of air in the siphon, so that the solution becomes slightly turbid on standing; but this effect of oxidation can be easily avoided by using a sufficient amount of marble powder in charging the generator. This siphon unquestionably affords the most convenient mode of using hydric sulphide; and for a private laboratory a single siphon, well charged, will afford as ample a supply as will ordinarily be needed. It is greatly to be hoped that our manufacturing chemists may soon find an advantage in supplying this important reagent in such an elegant form.*

When the water is charged as directed above, it of course holds in solution, besides hydric sulphide, a considerable volume of carbonic dioxide; and if, under any circumstances, the presence of this last gas would produce an injurious effect, the marble powder can be simply omitted in charging the generator. In almost all cases, however, the carbonic dioxide exerts a very beneficial influence, and in several ways. In the first place, it insures the non-action of the hydric sulphide on the metallic surfaces of the apparatus. In the second place, it protects the solution from the action of the air when it is drawn into an open vessel, so that after a metallic sulphide has been precipitated by an excess of the reagent, the products may be digested in an open flask or beaker without fear of oxidation. In the third place, the carbonic dioxide adds greatly to the tension of the confined gas, and enables us to develop sufficient pressure to charge the siphon without unnecessarily increasing the strength of the solution of hydric sulphide.

Chemical Laboratory of Harvard College, 1876.

ART. XLVIII.—*Report on the Physical Investigations carried on by P. Herbert Carpenter, B.A., in H.M.S. "Valorous" during her Return Voyage from Disco Island in August*, 1875; by WILLIAM B. CARPENTER, C.B., M.D., F.R.S.†

IN the first of the Serial Soundings taken by the "Valorous," nearly in the middle of Davis Strait and on the parallel of Godthaab, the bottom-temperature, at a depth of 410 fathoms, was 34·6° Fahr.; and the descent to this from a surface-temperature of 40° was nearly uniform—39°, 38°, 37°, 36° and

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* All the apparatus here described may be obtained from the firm of John Matthews, First Avenue, 26th and 27th Streets, New York, at very reasonable rates. Be careful in ordering to state the use to which the apparatus is to be put, with the caution that no silver plating or lead paint should be used upon it.

† Proc. Roy. Soc., vol. xxv, No. 173, p. 230, June 15, 1876.

35° being met with at almost equal intervals. There was here, therefore, no indication of any contrary movement of different strata of water, or of any special superheating of the superficial stratum. But the case was very different with the next much deeper sounding which was taken about a degree further south, but still toward the middle of Davis Strait: for there was here a surface-stratum of 45°, but of such extremely small thickness, that the isotherm of 40° was reached in about fifteen fathoms; from 40° to 38° the interval was nearly the same as in the previous sounding; but below 38° the descent was so slow that 37° was not reached until nearly 800 fathoms, and on the bottom at 1100 fathoms the temperature was still 36·4°. At the next station, latitude 62° 6′ N., longitude 55° 56′ W., (that is, another degree further south, and at about the same distance from the Greenland coast), a depth of 1350 fathoms was met with; the surface-temperature was still 45°; but the bottom-temperature was found to be 34·6°, as in the 410 fathoms sounding. The next temperature-sounding was taken nearly three degrees further south and five and one-half degrees to the west, namely, in latitude 59° 10′ N., longitude 50° 25′ W.; that is, a little to the south of Cape Farewell, but still six degrees to the west of it: here the surface-temperature was still 45°; but the bottom-temperature at 1,750 fathoms had sunk to 33·4°. Finally, a set of serial soundings was taken before rounding Cape Farewell, about a degree further south and four degrees east: the surface-temperature had then risen to 49°; but the isotherm of 40° was reached at about fifty fathoms, that of 39° at about ninety fathoms, and that of 38° at about 160 fathoms; while below this the descent of the thermometers was extremely slow down to the isotherm of 37°, which lay at about 1050 fathoms—becoming more rapid, however, beneath this, so that 36° was reached at about 1400 fathoms, 35° at about 1500, and 34·3° on the bottom at 1660 fathoms.

Now these phenomena seem to me to point very distinctly to the existence (1) of a superheated layer, which is slowly moving up Davis Strait, and gradually losing its excess of temperature as it proceeds north, as shown by the gradual approach of the isotherms to the surface; (2) of a neutral intermediate layer, 1,000 fathoms or more in thickness, marked out by the extreme uniformity of its temperature, which indicates its stationary condition; and (3) of a deep cold layer, which as clearly derives its low temperature from a northern source, as the uppermost stratum does from a southern, and which must, therefore, be in movement.

The temperatures at Station VI seem at first sight rather anomalous when compared with those of Stations VII–X—the isotherm of 37° here coming up within 200 fathoms of the surface, while at only a degree farther south it lies at nearly 800 fathoms; and a bottom-temperature of 34·6° being found at 410 fathoms at Station VI, while at Station VIII it is only reached at 1,350 fathoms. But the anomaly disappears when the rapidly increasing depth and the tendency of the coldest water to gravitate to the bottom are taken into account: for it appears, from the temperature-soundings taken further north toward Disco Island by the Swedish ship "Ingegera," that water as cold as this, and even much colder (31° being recorded in one instance), is there found at depths varying between fifty-eight and 185 fathoms; and it can scarcely be doubted that the water which is chilled by the more severe cold of Baffin's Bay is here flowing down the slope of Davis Strait. Again, it is at first sight an anomaly to find at Station VIII a bottom-temperature of 34·6° at 1,350 fathoms, while the bottom-temperatures both to the north and to the south of it are 34·6°; but this only shows that the coldest polar water is flowing south through some deeper channel, perhaps in the western half of Davis Strait.* And the same explanation applies to the yet more remarkable fact that a bottom-temperature of 33·4° was met with near the mouth of Davis Strait, when no such water was met with further north. But that even this does not carry down the coldest water of the Arctic basin, is obvious from the fact brought to light by the "Porcupine" temperature-soundings in the "Lightning Channel," (between the north of Scotland and the Faröe Islands), over a large part of whose bottom we found the temperature to range two degrees, or even more, *below* 32°.

The next temperature-sounding, taken on the 17th of August almost exactly in the meridian of Cape Farewell, and not quite two degrees to the south of it, gave, like No. IX, a bottom-temperature of 33·4° at 1,860 fathoms; so that it seemed pretty clear that this is the temperature of the coldest water that can find its way into the North Atlantic along either the west or the east coast of Greenland. And from the depth at which the isotherm 35° was found to lie in the 1660 fathoms serial sounding, it is obvious that the stratum between 35° and 33·4° must be here a very thin one; while the upward slope which is indicated by the next sounding, shows that it must rapidly die out toward the east.

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* As I pointed out on a former occasion, (Proc. Roy. Soc., vol. xx, p. 624, § 144), any water moving from either pole toward the equator will have a *westerly* tendency in virtue of its *deficiency* of easterly momentum; just as water moving from the equator toward either pole will have an *easterly* set, in virtue of the *excess* of easterly momentum which it carries with it. The later temperature-soundings of the "Challenger" in the South Atlantic have given the explanation of the temperature of 32·4° observed under the equator in the first year of her voyage, but not encountered in any of the earlier temperature-soundings taken in the South Atlantic, by showing that the coldest Antarctic underflow is met with on the *westerly* part of its sea-bed.

The course of the "Valorous" having then been kept at first nearly due east, and afterward southeast, another serial temperature-sounding was taken on the 19th of August, in latitude 56° 11′ N., and longitude 37° 41′ W. The surface-temperature had here risen to 53°,—about the same as we had encountered in the "Lightning Channel," at the same time of the year, rather farther to the north; but the warm upper stratum was here thinner, a reduction to 45° taking place within fifty fathoms, and to 40° within 300; whereas in latitude 59° 35′ N., longitude 9° 11′ W., we had found the isotherm of 45° lying below 500 fathoms, while the bottom at 767 fathoms was still 41·4°. It is obvious moreover, from the regularity of the descent of the isotherm of 40° in this part of the North Atlantic, that *easting* has more influence on the rate of that descent than *southing*—thus confirming the view formerly expressed as to the tendency of the warm upper flow toward the *eastern* side of the basin.* The isotherms of 39° and 38° slope downward toward the east at about the same rate; but those of 37° and 36° still nearly keep their parallelism to the surface, confirming the previous suggestion of the "neutrality" of the deep stratum which they underlie.

Between the last station and the next, taken in latitude 56° 1′ N., and longitude 34° 42′ W., in the line of the channel between Iceland and Greenland, but considerably to the south of it, the sea-bed was found to have shallowed most remarkably, bottom being struck at 690 fathoms, and the bottom-temperature rising again to 38·2°. This elevation may be regarded with great probability as a continuation of that which was encountered by Sir L. McClintock in the line of temperature-soundings which he took several years ago across the North Atlantic between Rockall and Cape Farewell; for almost exactly in a line between the "Valorous" Station 13 and Iceland, Sir L. McClintock met with bottom at 743 fathoms, between 1,260 fathoms on the east and 1,159 fathoms on the west.

The course being now again kept nearly due east, another temperature-sounding was obtained in latitude 55° 58′ N., longitude 31° 41′ W., which, on a bottom of 1,230 fathoms, gave a bottom-temperature of 36·8°, the surface-temperature being 54·5°. Three degrees farther east, and on the same parallel, another set of serial temperatures was taken, which indicated a further increase in the upper warm stratum, the isotherm of 40° descending to about 380 fathoms; but the depths of the isotherms of 39°, 38° and 37° show little change; and the bottom at 1,485 fathoms was 36·5°, as at the corresponding depth on the other side of the ridge. Still farther to the east, in latitude 55° 10′ N., longitude 25° 58′ W., the depth was found to have still further increased to 1,785 fathoms; but the bottom showed no lower a temperature than 36·7°, although in the 1,750 fathoms sounding on the other side of the ridge the thermometer fell to more than *three degrees lower.*

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* Shearwater Scientific Researches, 1872, §§ 144, 148, (Proc. Roy. Soc., xx, pp. 624, 626).

Bad weather having come on, it was not considered prudent, in the disabled condition of the ship, to attempt further scientific explorations; and the course was accordingly shaped for Cork.

The Temperature-Section prepared from the serial soundings taken in the "Valorous" after quitting Davis Strait has been continued toward Valentia on the basis of the serial soundings taken off the coast of Ireland in the first cruise of the "Porcupine" in 1867, a sounding in 1,263 fathoms, latitude 56° 8′ N., longitude 13° 34′ W., being taken as the principal guide. This being almost on the same parallel with the last serial sounding of the "Valorous," (the difference of latitude being only half a degree), and the seasonal difference being rather in favor of the "Valorous" temperatures, it is extremely striking to find in this section the most remarkable contrast yet brought out between the thermal condition of the eastern and the western sides of the North Atlantic: for the descent of all the isotherms as they pass from west to east, which has been already pointed out in the "Valorous" portion of the section, continues at an even more rapid rate; so that the isotherm of 40°, which lay at Station XVI at 380 fathoms, lies at 900 fathoms at Station XVII, fifteen degrees to the west; while the isotherm of 45°, which at the first of these stations lay at eighty fathoms from the surface, lay in the second at 640 fathoms. This difference in the thickness of the whole stratum above the isotherm of 40° is much more remarkable than the difference of surface-temperature, the increase of which between the first and the second station was only from 55° to 59·6°.

It is clear, therefore, that the heating power of the warm flow which comes up from the southwest toward the western shores of the British Isles, and which proceeds onward to the northeast, so as to ameliorate the climate of the Orkneys and Shetland Islands, but still more markedly to affect that of the coast of Norway (as has been shown by Professor Mohn), depends upon *its great depth.* Any such superheated film as the Gulf-stream has been found to be when last recognizable as a current (as was long since urged by Mr. Findlay, and has since been confirmed by Capt. Chimmo's observations), must lose its excess of warmth long before it reaches our shores.

Hence, as I have urged on a former occasion, the prolonged heating power of the northeast flow depends much more upon the thickness of its moderately warm stratum than upon its bringing with it a high surface-temperature. A layer of fifty fathoms at 60°, flowing northeast over a bed of ocean-water at 40°, and exposed above to an atmosphere of 40°, would be cooled down to that standard in two or three weeks. But a layer of 900 fathoms thickness, ranging from 40° to 55°, would retain an excess of temperature far longer.

The advocates of the doctrine that the *vis a tergo* is the Gulf-stream, which cannot be traced as a current by any distinctive feature further to the northeast than the parallel of 40° and the meridian of 30°, have to show in what way it can raise the temperature of so thick a stratum of ocean-water as we have seen to be affected in the western portion of the North Atlantic by a warm flow of some kind. Whether, as Professor Wyville Thomson maintains, the approximation of its boundaries between the British Islands on one side and Labrador and Greenland on the other can possibly produce this result, is a point on which it is for hydrographers to decide. For myself, I cannot regard it as probable that a spent stream of fifty fathoms thickness can give motion to a vast layer of 900 fathoms depth.

On the other hand, the doctrine I advocate, that a thick upper stratum of the North Atlantic is slowly moving poleward, to fill up the void left by the gravitation-underflow of the coldest water toward the equator, and that this stratum will also have an easterly tendency in virtue of the excess of easterly momentum which it brings with it from a lower latitude, seems adequately to account for the facts now brought to light. The progressive closing in of the boundaries of this poleward upper flow will obviously tend to deepen it, so as to give it a more persistent heating power.* In the South Atlantic and Southern Indian Oceans, on the other hand, the progressive opening-out of the ocean-boundaries, as we pass southward from the equator, will tend in the same measure to reduce the thickness of the poleward upper flow, thus diminishing the persistence of its heating power. And in this, as it seems to me, we have the true explanation of the marked difference between the climate of Kerguelen's Land (latitude 50° S.), for example, or that of Heard Island (latitude 53° S.), and that of Ireland, (lying between the parallels of 51½° and 54½° N. latitude), the summer temperature of the former being but little above the winter temperature of the latter.

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* This position may seem inconsistent with the objection just taken to the doctrine of Sir Wyville Thomson. But the inconsistency is only apparent. I cannot conceive that after the Florida Current has spread itself out like a fan over the Mid-Atlantic, it can retain enough *vis a tergo* to give a northeast movement to a mass of water nearly 2,000 miles wide and 700 or 800 fathoms deep, the impelling force being progressively weakened by the obstacles to that movement. On the other hand, the force which (on the doctrine of a Thermal circulation) acts as a *vis a fronte*, grows stronger as the water which it puts in motion approaches the polar area, and thus is fully competent to deepen the poleward stratum in proportion to the reduction of its breadth.

The "Challenger" temperature-sections have most conclusively shown that the entire warm upper stratum in the South Atlantic is very much thinner than that of the North Atlantic; and while I fully admit that a part of this difference is due to the fact that a far larger portion of the equatorial current is deflected into the latter than into the former, I cannot see that the Gulf-stream by any means accounts for the descent of the isotherm of 40° in latitude 56° N. to a depth of 900 fathoms.

The "Valorous" temperature-soundings seem to me to be of peculiar interest and value, in furnishing a satisfactory explanation of the comparatively high bottom-temperature of the North Atlantic. I have always attributed this to the comparative narrowness of the channels of communication between the Arctic and the North Atlantic basins, which restrict the flow of the coldest polar water from the former into the latter; and long before the "Challenger" Expedition sailed, I had ventured the prediction that the South Atlantic, on account of the perfect freedom of its communication with the Antarctic, would have a colder bottom, and that the influence of the Antarctic underflow would probably extend to the north of the equator. By Sir Wyville Thomson, on the other hand, it was argued from the commencement that the whole cooling of the deep stratum of the *North* Atlantic is due to the *Antarctic* underflow; and this conviction he repeats in his last utterance on the subject, on the ground of the continuity of the isotherms from the South into the North Atlantic.* The question arises, however, why the deep stratum of the North Pacific, which is undoubtedly fed from the Antarctic, should be so decidedly colder, as the "Challenger" and "Tuscarora" soundings show it to be, than the deep stratum of the North Atlantic; and this question appears to me to find an entirely satisfactory answer in the indication furnished by the Second Section, that the Arctic Basin is for the most part separated from that of the North Atlantic by an intervening ridge, which (like many similar ridges discovered by the "Challenger") allows water of about 36°, but *not colder water*, to pass from the former into the latter. The limited contributions of colder water furnished by Baffin's Bay and the "Lightning Channel" would help to reduce the deep temperature of the North Atlantic generally to the 35°–36° shown in the "Challenger" Sections; but it is only when, on approaching the equator, a bottom-temperature below this first shows itself, that I can recognize the influence of the Antarctic underflow.

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* **Proceedings of the Royal Society, vol. xxiv, p. 632.**

I forbear, however, to discuss this subject more fully at present, the Admiralty not having yet published the final installment of the "Challenger" temperature-sections. And I shall confine myself to an expression of my earnest hope that the ship to be sent next year to communicate with the Arctic Expedition may have, as part of its work, the completion of that which the "Valorous" was disabled from performing—namely, the obtaining a continuous temperature-section between Iceland and Greenland, and another across Davis Strait.

ART. XLIX.—*On the Influence of Geological Changes on the Earth's Axis of Rotation*;[*] by GEORGE H. DARWIN, M.A., Fellow of Trinity College, Cambridge. Received by the Royal Society October 13, 1876.[†]

THE subject of the fixity or mobility of the earth's axis of rotation in that body, and the possibility of variations in the obliquity of the ecliptic, has of late been attracting much attention; but the author believes that it has not hitherto been treated at much length. The paper, of which the following is an abstract, is an attempt to investigate the results of the supposition that the earth is slowly changing its shape, with especial reference to the effects on the obliquity of the ecliptic and on the geographical position of the earth's axis of figure.

1. This part of the paper is devoted to the consideration of the precession and nutations of an ellipsoid of revolution which is slowly and uniformly changing its shape. The change is supposed to proceed from causes internal to the earth, and only to continue so long as the total changes in the principal moments of inertia C and A remain small compared to their difference, C—A.

The problem is treated by means of M. Liouville's extension of Euler's equations of motion of a rigid body about a point.[†] By an approximate method these equations may be treated as linear, and the solution divided into two parts.

Let θ be the obliquity of the ecliptic; π cosec θ the precession of the equinoxes; $-n$ the angular velocity of rotation of the ellipsoid; $A+at$, $A+bt$, $C+ct$ the principal moments of inertia at the time t. Then it is shown that the secular effect on the obliquity of the ecliptic, as resulting from the motion of the principal axes in the body (which constitutes the first part of the solution), is given by the equation

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[*] Since this paper was in manuscript Sir William Thomson has delivered his address to the Mathematical Section of the British Association at Glasgow. He therein touches on this subject, and gives some of the results attained here; but as he has not stated how he has attacked the problem, and as the subject has been recently attracting much attention, the author still ventures to offer his paper to the Royal Society.

[†] Abstract of Mr. Darwin's Memoir, from the Proceedings of the Royal Society xxv, No. 175, 328.

[†] Liouv. Journ., 2^{e} série, t. iii, 1858, p. 1; Routh's Rigid Dynam., p. 150.

$$\frac{d\theta}{dt}=-\frac{\Pi}{2n}\,\frac{a+b-2c}{A};$$

and as resulting from the change in the impressed forces, due to the change of shape of the body (which constitutes the second part), is given by

$$\frac{d\theta}{dt}=\frac{\Pi}{2n}\,\frac{a+b-2c}{C-A}.$$

The former part may be neglected compared with the latter. But from such geological changes as we are entitled to assume in the case of the earth, the total change in the obliquity of the ecliptic must be exceedingly small. Even gigantic polar ice-caps during the Glacial period could not have altered the position of the arctic circle by so much as three inches; and this is the most favorable redistribution of matter on the earth's surface for producing that effect. Thus the obliquity of the ecliptic has remained sensibly constant throughout geological history.

It is also shown that, during any gradual deformation of the ellipsoid, the instantaneous axis of rotation will always remain sensibly coincident with the principal axis of figure.

In the course of the work by which the previous results are attained there is shown to be a small inequality in the motion of the instantaneous axis, in consequence of which that axis describes a circle with uniform velocity, and is coincident with the axis of figure every 306th day (in the earth). This circle touches the meridian along which the axis of figure is traveling in consequence of the deformation of the earth's shape. The diameter of the circle is shown in a particular case (not unfavorable to produce a large effect) to be less than $\frac{1}{378}''$. But although this inequality appears to be so small, it is of interest and is discussed at some length. It is shown that, if the earth be not quite rigid, this inequality might have the effect of modifying the path of the axis of figure in the body, in consequence of readjustments to a figure of equilibrium.

Various hypotheses as to the power of adjustment are considered, and the paths of the instantaneous and principal axes in the precession of a viscous spheroid undergoing deformation are found.

It is maintained that although the earth may be sensibly rigid to the tidally deforming forces exercised by the sun and moon, it would not be so to considerable departures from the figure of equilibrium, such as would arise from a wandering of the pole of figure from its initial position; and that readjustments to an approximate form of equilibrium probably take place, at considerable intervals of time, impulsively by means of earthquakes. Such periodical adjustments would not sensibly modify the geographical path of the principal axis as due to terrestrial deformation. But it is held that during the consolidation of the earth there must have been great instability in the geographical position of the poles. Throughout the rest of the inquiry, however, the hypothesis of the earth's sensible rigidity, together with the possibility of more or less rare impulsive readjustments to the figure of equilibrium, is adhered to. In consequence of these results dynamical considerations may be dismissed, and it only remains to consider the kinematical question of the change in the earth's principal axes due to any deformation of its shape.

2. Formulæ for this end are here found, and are adapted for numerical calculation. It is assumed, in the first place, that the deformation is such that there is no change in the strata of equal density; and accordingly all suppositions as to the nature of the internal changes accompanying geological upheaval and subsidence are set aside.

3. The forms of continent and depression are next investigated, which, for the transport of a given quantity of matter from one part of the earth's surface to another, would cause the maximum deflection of the principal axis of greatest moment—subject, however, to the condition that the layer excavated or piled up shall nowhere exceed a given small fraction of the earth's radius.

It is shown that the continents and depressions must be of uniform height and depth; there must be two of each, all similar to one another; that each has one of its own kind diametrically opposite to it; that they are in shape sphero-conics, formed by the intersection of a certain elliptic cone with the sphere; that the centers of the four sphero-conics are all on the same *complete* meridian and all in latitude 45°. A table of numerical results depending on the values of certain elliptic functions is given.

4. In this part an endeavor is made to collect evidence as to the extent to which the earth may have undergone deformation from geological changes. The object is to discover what are the largest areas over which there has been a consentaneous rise or fall, and what is the greatest vertical amount of that rise or fall; also to determine how the erosion of the land and the sea affect the local excesses or deficiencies of matter on the earth's surface. The areas and amounts of elevation and subsidence

which on a sealess and rainless globe are equivalent, as far as producing excesses or deficiencies of surface matter, to those which obtain on the earth are referred to as "effective;" and it is only the effective elevation or subsidence which we require to know in order to determine the shift of the earth's axis.

The evidence as to area is very meager, because precise boundaries to regions of elevation and subsidence cannot be assigned; but, *faute de mieux*, the author's father, Mr. Charles Darwin, marked out for him on a map an area in the Pacific Ocean which (on account of the structure of the coral islands) he believes to have undergone subsidence within a recent geological period. From a consideration of this and of other points the author believes that from $\frac{1}{16}$ to $\frac{1}{25}$ of the whole earth's surface may, from time to time, have undergone elevation and subsidence. The greatest vertical effective amount of rise or fall cannot be determined from geological evidence, because of the effects of erosion and of the influx of the sea into parts below the mean level of the earth.

The only way of determining the point seems to be to find what is the difference of mass, standing on unit area of the earth's surface, in an ocean of, say, 15,000 feet deep, and in land of, say, 1100 feet high. From this difference of mass the effective elevation of an ocean-bed in its conversion into land can be at once determined. Taking the above numbers, it is found to be 10,436 feet; and in the examples given in the following part, the deflection of the polar axis, for an assumed effective elevation of 10,000 feet, is given in each case.

It is then pointed out that, if the deformation of the earth were of very wide extent, the level surface of the sea would approximately follow the rocky surface, and that thus there might be sufficient change in the earth's shape to sensibly affect the position of the principal axis, without there being any geological signs of elevation or subsidence.

5. Numerical application is now made of the preceding work to the case of the earth, and, as before stated, all the results are given for 10,000 feet of effective elevation.

The first application is to continents and seas of maximum effect, and a table of results is given. It may be here stated that if $\frac{1}{360}$ of the earth's surface is elevated, the deflection of the pole is $11\frac{1}{3}'$; if $\frac{1}{25}$, $1^\circ\ 46\frac{1}{2}'$; if $\frac{1}{16}$, $3^\circ\ 17'$; and if $\frac{1}{2}$, $8^\circ\ 4\frac{1}{2}'$.* In each case an equal area is supposed to fall simultaneously.

Other examples are then given for continents and seas which do not satisfy the maximum condition; in some the boundaries are abrupt cliffs, in others shelving.

The conclusion is arrived at, that a single large geological produce an alteration in the position of the pole of from one to change, such as those which obtain on the earth, is competent to three degrees of latitude, on the hypothesis that there is no change in the law of internal density.

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* The area of Africa is about ·059, and of South America about ·033 of the earth's surface.

6. Various hypotheses as to the nature of the internal changes accompanying the deformation of the earth are discussed.

First, it is shown that if upheaval and subsidence are due to a shrinking of the earth as a whole, but to the shrinking being quicker than the mean in some regions and slower in others, the results are the same as those previously attained.

Second, the increase of surface matter due to the deposit of marine strata also gives the same results.

Third, the hypothesis that upheaval and subsidence are due to the intumescence or contraction immediately under the regions in question is considered. Under certain special assumptions, too long to recapitulate, it is shown that the previous results must be largely reduced. A table of the values of the reducing factor for various thicknesses of the intumescent strata is given; from which it appears that if the stratum is tolerably thin and at all near the surface, the deflection of the pole is reduced to quite an insignificant amount. Even if the intumescence extends right down to the center of the earth in a cone bounded by the elevated region, the results would be only about ⅔ of the former ones. Hence it appears that the earlier results can only be stated as a superior limit to what is possible.

7. In conclusion it is pointed out that if the earth be quite rigid, no redistribution of matter in new continents could ever cause the deviation of the pole from its primitive position to exceed the limit of about 3°. But if the previously maintained view is correct, that the earth readjusts itself periodically to a new form of equilibrium, then there is possibility of a cumulative effect; and the pole may have wandered some 10° or 15° from its primitive position, or have made a smaller excursion and returned to near its old place. No such cumulation is possible, however, with respect to the obliquity of the ecliptic.

It is suggested that possibly the glacial period may not have been really one of great cold, but that Europe and North America may have been then in a much higher latitude, and that on the pole retreating they were brought back again to the warmth. There seem to be, however, certain geological objections to this view.

ART. L.—*On a Base derived from a Waste-product in the Aniline Manufacture;* by C. LORING JACKSON.

IN the spring of 1875 under the direction of Prof. A. W. Hofmann I investigated a waste-product from the factory of Drs. Martius and Mendelssohn-Bartholdy at Rummelsburg near Berlin, which was obtained after the toluidine had passed over in the annual rectification of the highest fractions from the aniline-oil distillation. The results I then obtained were published in the Berichte der Deutschen Chemischen Gesellschaft for 1875, page 968, and may be briefly restated as follows by way of introduction to my subsequent work.

The substance, a black oily liquid, was dissolved in strong hydrochloric acid, and freed from tar by repeated filtration; the oily base set free by sodic hydrate was then fractioned, and yielded at first xylidine and allied bodies which were not further examined; later a fraction from 280° to 320° which, after removal of naphtylamine with dilute sulphuric acid, was converted into a nitrate and purified by crystallization; it then formed radiated groups of white needles which gave on analysis:

	Calculated for $C_{13}H_{14}NNO_3$.	Observed.
Carbon	63·41	63·38
Hydrogen	5·69	5·66

By heating with nitric acid a magenta-colored substance was formed which rendered it very difficult to obtain the salt white.

The *sulphate* was very soluble.

The *chloride* $C_{13}H_{14}NCl$ crystallized in white flat needles.

The *platinum salt* $(C_{13}H_{14}N)_2PtCl_6$ crystallized in very characteristic fan-like groups of sparingly soluble light yellow needles often more than half a centimeter long. The analysis gave

	Calculated.	Found.
Platinum	25·36	25·39
Carbon	40·08	38·78
Hydrogen	3·59	3·82

The *free base* $C_{13}H_{13}N$ was obtained as an oil which gave with chloroform and potassic hydrate a smell similar to that of the isocyanides; it was therefore a primary amine, and its formula must be written $C_{13}H_{11}NH_2$.

An *acet-compound* $C_{13}H_{11}NHC_2H_3O$ was also prepared by the action of acetyl-chloride on the free base; it crystallized in white needles and melted at 114°·25. At that time also some attempts were made to obtain synthetically a base with the same formula, but the results were not published.

At the beginning of the next year, T. Carnelly* described a base $C_{12}H_{11}NH_2$ formed by the reduction of mononitrotolylphenyl made synthetically, but as he did not describe either the acet-compound or the platinum salt there were no data for a comparison of his base with mine; to furnish such data is the object of the present paper. Carnelly found that, on addition of sodic hydrate to a salt of his base and extraction with ether, on evaporating the ether "an oily body was first produced from which there separated out a small quantity of needle-shaped tufts. The melting-point of these after careful drying was found to be 93°–97°." Under the same conditions my base also furnished an oil, but at the time of the investigation in Berlin I observed no crystals. In the hope that longer standing would cause it to solidify I have since the publication of Carnelly's paper, precipitated the small quantity of the salts of my base still at my disposal with sodic hydrate and allowed the brown oil thus obtained to stand under a bell-jar; after several days crystals appeared, and in a few weeks it had changed nearly completely into good-sized prismatic crystals arranged in pennate groups which broke up on pressure into rough octahedral masses. Freed by means of filter-paper from a little adhering brown oil these crystals melted at 46°–70°; from an ethereal solution the substance separated as a brown oil solidifying on stirring to pennate plates with the same melting-point as before recrystallization. The crystals were insoluble in water, freely soluble in alcohol, ether and benzol, and instantly converted by hydrochloric acid into a chloride which dissolved easily in water and was obtained crystallized in white flattened needles two and a half centimeters long melting with partial decomposition near 200°, whereas Carnelly's crystalline base when heated with hydrochloric acid "dissolved only after long boiling; on cooling, small fine white silky needles were deposited, which were separated from the mother-liquor, washed with a little water and dried over lime, after which they were found to melt, with blackening, at 280° to 283°."

From this comparison it is evident that the base described by Carnelly is not identical but isomeric with that obtained by me, and this view is further confirmed by the fact that the fan-shaped crystal-groups of the platinum salt of my base were so characteristic that Carnelly would have certainly described them had his platinum salt appeared in this form.

Finally, it is worth mentioning that in 1875 I had, as announced at the end of my first paper, attempted to prepare synthetically a base with this formula, and even after the publication of Carnelly's paper, as my method was different from his, I determined to bring the experiments for which I had provided material to a conclusion before abandoning the field to him; the work however was delayed by other and more important researches and it was not until this winter that I was ready to examine the products of the reaction of sodium on a mixture of parabromanilin and parabromtoluol; just as I had proved the absence of any base other than bromanilin I received the paper* Ueber eine neue Bildung des Azobenzols by R. Anschuetz and G. Schultz and guided by it have succeeded in detecting also the azobenzol. I can therefore confirm the results recorded in that paper in every particular.

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* Journ. Chem. Soc., II, xiv, 21.

To avoid interfering with any of the above-named gentlemen I intend to abandon this line of research.

Chemical Laboratory of Harvard University, Cambridge, Mass., March 3d, 1877.

ART. LI.—*On an association of Gold with Scheelite in Idaho;* by B. SILLIMAN.

A CORRESPONDENT in Idaho has lately sent me a specimen, obtained from a mineral vein, in which native gold is associated with scheelite and quartz. On account of some resemblance in color to grossular garnet, the miners mistook the scheelite for this species. But the high density of the mass at once attracts attention and a trial for hardness alone proves it is not garnet. The pyrognostic characters also show the absence of silica and the presence of tungstic acid. The powdered mineral treated with hydrochloric acid develops at once the characteristic yellow of tungstic acid, and zinc converts this solution to the familiar blue of tungstic oxide.

The gold appears in the scheelite, intimately associated with a small amount of pyrite, interspersed in the mass of scheelite and quartz. The pyrite is considerably decomposed, yielding yellowish-brown oxide of iron, and some green stains indicate also chalcopyrite, traces of which are detected by close observation. Leucopyrite is also present in minute quantities. But the total quantity of sulphides is certainly not over 1 to 1½ per cent of the mass, if so much.

The scheelite is massive, with few crystalline faces; its color is yellow-brown, resembling chondrodite. Portions of it are quite free from quartz or any mineral but gold. I found the density of the entire mass (weighing 379·42 grams) to be 3·27. Taking the density of quartz =2·66, and of scheelite =6, and disregarding the minor constituents of the mass, the proportions of these two minerals is as 270 : 109·37, or 2·46 parts of quartz to 1 part of scheelite. This is doubtless much above the average amount of scheelite in the vein, as a whole, but the high density of the tungstate renders its separation from quartz by mechanical dressing an easy matter, and suggests this as a valuable resource for tungstic acid, the value of which in the form of sodic tungstate, for fire-proofing textile fabrics, is well understood. *Locality.*—Charity Mine, Warren's, Idaho Territory.

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* Ber. Deutsch. Chem. Gesellschaft, ix, 1398.

My correspondent says: "The miners on this ledge (lode) lately struck a pocket of ore similar to that I send, and in a few evenings pounded out in a hand mortar about one thousand dollars, gold value, from a few candle boxes full of ore. The ore usually pays about twenty dollars per ton."

The affinities of mineral association indicate that cassiterite and wolfram may reasonably be looked for in the future exploration of this interesting vein.

Since writing the above, I have learned of another and much more interesting example of the occurrence of gold in scheelite, from Golden Queen Mine, Lake Co., Colorado. The gold is in minute crystalline granules in the scheelite and fills what appears to have been a geode of scheelite crystals.

New Haven, April 19, 1877.

ART. LII.—*Ninth Report of the British Association Committee, appointed for the purpose of investigating the Rate of Increase of Underground Temperature downward in various Localities of Dry Land, and under Water;* drawn up by Prof. EVERETT, Secretary of the Committee.*

A REMARKABLE series of observations have recently been taken in a boring at Sperenberg, near Berlin. The bore was carried to the depth of 4,052 Rhenish (or 4,172 English) feet, and was entirely in rock salt with the exception of the first 283 feet, which were in gypsum with some anhydrite. The observations were taken under the direction of Herr Eduard Dunker, of Halle-an-der-Saale, and are described by him in a paper occupying thirty-two closely printed quarto pages (206–238) of the Zeitschrift für Berg-Hütten-und-Salinen-Wesen (xx Band, 2 und 3 Lieferung, Berlin, 1872).

The instrument employed for measuring the temperature was the earth-thermometer of Magnus, which gives its indications by the overflowing of mercury, which takes place when the instrument is exposed to a higher temperature than that at which it was set. To take the reading it was immersed in

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*** The committee consisted of Prof. Everett, Sir W. Thomson, Prof. J. Clerk Maxwell, G. J. Symons, Prof. Ramsay, Prof. A. Geikie, James Glaisher, George Maw, W. Pengelly, Prof. Hull, Prof. Ansted, Prof. Prestwick, Dr. C. Le Neve Foster, Prof. A. S. Herschel, G. A. Lebour, and A. B. Wynne.**

water a little colder than the temperature to be measured; the temperature of this water is noted by means of a normal thermometer, and at the same time the number of degrees that are empty in the earth-thermometer is noted. From these data the maximum temperature to which the instrument has been exposed can be deduced, subject to a correction for pressure, which is not very large, because the same pressure acts upon the interior as upon the exterior of the thermometer.

In the following *résumé* (as in the original paper) temperatures are expressed in the Réaumur scale, and depths in Rhenish feet, the Rhenish foot being 1·029722 English foot.

Observations were first taken at intervals not exceeding one hundred feet, from the depth of one hundred feet to that of 4042 feet, the temperature observed at the former depth being 11·0, and at the latter 38·5; but all these observations, though forming in themselves a smooth series, were afterward rejected, on the ground that they were vitiated by circulation of water and consequent convection of heat.

It has often been supposed that though this source of error may affect the middle and upper parts of a bore, it cannot affect the bottom; but the Sperenberg observations seem to prove that no such exemption exists. When the bore had attained a depth of nearly 3,390 feet, with a diameter of twelve inches two lines at the bottom, an advance bore of only six inches diameter was driven seventeen and one-half feet further. A thermometer was then lowered half-way down this advance bore, and a plug was driven into the mouth of this advance bore so as to isolate the water contained in it from the rest of the water above. After twenty-eight hours the plug was drawn and the thermometer showed a temperature of 36·6. On the following day the temperature was observed at the same depth without a plug, and found to be 33·6. Another observation with the plug was then taken, the thermometer (a fresh instrument) being left twenty-four hours in its position. It registered 36·5, and again, without plugging, it gave on the same day 33·9. It thus appears that the effect of convection was to render the temperature in the advance bore 3° R. too low.

Apparatus was then employed for isolating any portion of a bore by means of two plugs at a suitable distance apart with the thermometer between them. This operation was found much more difficult than that above described, but in several instances it gave results which were deemed quite satisfactory; while in other instances the apparatus broke, or the plugging was found imperfect. The deepest of the successful observations by this method was at 2,100 feet, and the shallowest was at 700 feet. The first 444 feet of the bore were lined with iron tubes, between which the water had the opportunity of circulating even when the innermost tube was plugged, hence the observations taken in this part were rejected.

All the successful observations are given in the third column of the following table, subject to a correction for pressure; and, for the sake of showing the error due to convection in the ordinary mode of observing, the temperatures observed at the same depths when no plugs were used, are given in the second column:

Depth in feet.	Temperature Reaumur.		Difference.
	Without plugging.	With plugging.	
700	16·08	17·06	0·98
900	17·18	18·5	1·32
1,100	19·08	20·8	0·72
1,300	20·38	21·1	0·72
1,500	22·08	22·8	0·72
1,700	22·9	24·1	1·2
1,900	24·8	25·8	1·0
2,100	26·8	27·1	0·3
3,390	34·1	36·15	2·05

These temperatures are not corrected for pressure, but they are corrected for rise of zero in the normal thermometer; and this last circumstance explains the difference of 0·4 between the temperature 36·15 here given and 36·55, which is the mean of the above-mentioned observations at the depth of 3,390 feet.

Another proof of the injurious effect of convection was obtained by comparing the observed temperatures (without plugging) in the first 400 feet of the great bore, designated Bore I, with the temperatures observed at the same depths during the sinking of another bore, designated Bore II, near it; the observations in this latter being always taken at the bottom. The following were the results:

Depth in feet.	Temperature.	
	Bore I.	Bore II.
100	11·0	9·0
200	11·6	10·4
300	12·3	11·5
400	13·6	12·5

The temperature at the depth of one hundred feet in the great bore thus appears to have been raised about 2° R. by convection.

The following is a table of the successful observations, corrected for pressure:

Depth in Rhenish feet.	Temperature Reaumur.
700	17·275
900	18·780
1,100	21·147
1,300	21·510
1,500	23·277
1,700	24·741
1,900	26·504
2,100	28·668
3,390	37·238

Assuming, with Herr Dunker, the mean temperature of the surface to be 7·18, which is the mean annual temperature of the air at Berlin, we have the following increments of temperature with depth:

Depth in Rhenish feet.	Increment of depth.	Increment of temperature.	Increase per 100 feet deg. Reaumur.	Increase per 100 feet deg. Fahr.
0 to 700	700	10·095	1·442	3·24
800 to 900	200	1·505	·752	1·69
700 to 1,100	200	2·367	1·184	2·66
1,100 to 1,300	200	0·363	·182	·41
1,300 to 1,500	200	1·767	·884	1·99
1,500 to 1,700	200	1·464	·732	1·65
1,700 to 1,900	200	1·763	·882	1·98
1,900 to 2,100	200	2·164	1·082	2·43
2,100 to 3,390	1,290	8·570	·664	1·49
0 to 3,390	3,390	30·058	·887	2·00

The mean rate of increase found by comparing the temperatures at the surface and 3.390 feet is exactly 1° Fahr. for 50 Rhenish or 51·5 English feet.

The numbers in the last two columns exhibit upon the whole a diminution with increase of depth; in other words, the temperature increases less rapidly as we go deeper down. As regards the first 700 feet, which exhibit a decidedly more rapid rate than the rest, it must be remembered that nearly half of this distance was in a different material from the rest of the bore, being in gypsum with some anhydrite, while all the rest was in rock salt. Prof. Herschel has found, in recent experiments not yet published, that the conductivity of rock salt is exceedingly high; and theory shows that the rates of increase, in superimposed strata, should be inversely as their conductivities. We may, therefore, fairly attribute the rapid increase in the first 700 feet to the relatively small conductivity of the portion (283 feet) which is not rock salt. The slow rate of increase observed in the long interval between the depths of 2,100 and 3,390 feet is not so easily accounted for; we can only conjecture that this and the other inequalities which the above table presents, for depths exceeding 700 feet, are due to fissures and other inequalities in the rock which have not been put in evidence.

With the view of summing up his results in small compass, Herr Dunker has assumed the empirical formula:

$$t = 7{\cdot}18 + ax + bx^2,$$

t denoting the temperature (Réaumur) at the depth x (Rhenish feet); and has computed the most probable values of a and b, by the method of least squares. He finds

$$a = {\cdot}0129857 \qquad b = -{\cdot}000000125791,$$

the negative sign of b indicating that the increase of temperature becomes slower as the depth increases.

A paper by Prof. Mohr, of Bonn, as represented by an abstract published in *Nature* (vol. xii, p. 545), has attracted attention from the boldness of its reasoning in reference to the Sperenberg observations. Prof. Mohr, however, does not quote the observations themselves, but only the temperatures calculated by the above formula, which he designates, in his original paper (*Neues Jahrbuch für Mineralogie*, etc., 1875, Heft 4), "the results deduced from the observations by the method of least squares." In the abstract in *Nature* they are simply termed "the results of the thermometric investigation of the Sperenberg boring," a designation which is still more misleading. Attention is called to the circumstance that the successive increments of temperature for successive equal increments of depth, form an exact arithmetical progression, as if this were a remarkable fact of observation, whereas it is merely the result of the particular mode of reduction which was adopted, being a mathematical consequence of the assumed formula $t = 7{\cdot}18 + ax + bx^2$. The method of least squares is not responsible for this formula, but merely serves, after this formula has been assumed for convenience, to give the best values of a and b.

Herr Dunker, in his own paper, lays no stress upon the formula, and gives a caution against extending it to depths much greater than those to which the observations extend. Writing to Prof. Everet under date April, 1876, he requests that in the summary of his results to be given in the present Report, the formula should either be suppressed or accompanied by the statement that its author reserves a different deduction.

The following are the differences between the temperatures computed by the formula and the observed temperatures:

Depth.	Difference (computed *minus* observed).
700	−1·621
900	−0·931
1,100	−1·204
1,300	+0·427
1,500	+0·553
1,700	+0·882
1,900	+0·811
2,100	+0·238
3,390	+0·482

The necessity of adopting some means to prevent the circulation of water in bores, has for some time been forcing itself upon the attention of your committee. Many of the observations taken by their observers have contained such palpable evidence of convection as to render them manifestly useless for the purpose intended; and in the light of the Sperenberg experiment it is difficult to place much reliance on any observations taken in deep bores without plugging. The selection of a suitable form of plug is now occupying the careful attention of your committee.

Herr Dunker's paper gives a very full account of the different kinds of plug employed at Sperenberg.

For stopping the mouth of the advance-bore the plug had a tapering shape, and was of hard wood, strengthened by two iron rings, one at each end. and covered with a layer of tow five lines thick, outside of which was thick and strong linen, nailed above and below to the wood, through a leather strap. It was lowered into its place by means of the iron rods used for boring; and, when in position, was pressed home by a portion of the weight of the rods. The plug carried the thermometer suspended from it. Its extraction was commenced by means of a screw on the beam of the boring machine, in order to avoid a sudden jerk, which might have broken the thermometer. The force which was found necessary for thus starting the plug, as well as the impression observed upon it when withdrawn, showed that it had fitted tight. To insure a good fit, the top of the advance-bore had been brought to a suitable shape, and its inequalities removed, by means of a revolving cutting-tool. Herr Dunker remarks that this plan is adapted to a soft material like rock-salt, but that in ordinary hard rock it would be better to make the bottom of the main bore flat, and to close the advance-bore by an elastic disc pressed over it. The method of observation by advance-bores can only be employed during the sinking of the bore, a time when it is difficult to avoid error arising from the heat generated in boring. The expense of making an advance-bore at each depth at which an observation is required is also an objection to its use.

Another kind of plug devised by Herr Dunker, and largely used in the observations, consisted of a bag of very stout india-rubber (nine millimeters thick) filled with water, and capable of being pressed between two wooden discs, one above and the other below it, so as to make it bulge out in the middle and fit tightly against the sides of the bore. On the suggestion of bore-inspector Zobel, the pressure was applied and removed by means of screwing. Two steel springs fastened to the upper disc, and appearing, in Herr Dunker's diagram, very like the two halves of a circular hoop distorted into an oval by pressing against its walls, prevented the upper disc from turning, but offered little resistance to its rising or falling. The lower disc, on the contrary, was permitted to turn. Both discs were carried by the iron boring-rods. Rotation of these in one direction screwed the discs nearer together, and rotation in the other direction brought them farther apart. The india-rubber bag could thus be made to swell out and plug the bore when it was at the desired depth, and could be reduced to its original size for raising or lowering. In order to prevent the boring-rods from becoming unscrewed one from another, when rotated backwards, it was necessary to fasten them together by clamps, a rather tedious operation in working at great depths.

In taking observations at other points than the bottom, two of these plugs were employed, one above the other below the thermometer.

In some of the experiments, the apparatus was modified by using linen bags filled with wet clay, instead of india-rubber bags filled with water; and, instead of screwing, direct pressure was employed, the lower disc being supported by rods extending to the bottom of the bore, while the upper disc could be made to bear the whole or a portion of the weight of the rods above it. Some successful observations were obtained with both kinds of bag; but the water-bags were preferred, as returning more easily to their original size when the pressure was removed, and consequently being less liable to injury in extraction. In some observations since taken in another place (Sudenberg). Herr Dunker states (in the private letter above referred to) that india-rubber bags, filled with water, and pressed, not by screwing, but by the weight of the rods, were employed with much satisfaction.

All the methods of plugging employed by Herr Dunker involved the use of the iron rods belonging to the boring apparatus, and therefore would be inapplicable (except at great expense) after the operation of boring is finished and the apparatus removed.

It seems desirable to contrive, if possible, some plug that can be let down and raised by a wire. In the first report of your Committee, it was suggested that two bags of sand, one above and the other below the thermometer, should be used for this purpose. Bags of sand, however, would be liable to rub off pieces from the sides of the bore, and thus to become jammed in drawing up. Mr. Lebour has devised a plug which will be of small diameter during the process of lowering and raising, but can be rendered large and made to fit the bore, when at the proper depth, by letting down upon it a sliding weight suspended by a second wire. Sir W. Thomson suggests that a series of india-rubber disks, at a considerable distance apart, will probably be found effectual.

Mr. Boot has continued his observations in the bore which he is making at Swinderby, near Scarle (Lincoln). It has now been carried to the depth of 2,000 feet, and is in earthy limestone or calcareous shale, of Carboniferous age. Its diameter in the lower part is only 3⅛ inches. In April last the temperature, 78° F., was observed at 1,950 feet; and more recently 79° F. was observed at 2,000 feet; the water, in each case, having been undisturbed for a month. Supposing these results not to be vitiated by convection, and assuming the mean temperature at the surface to be 50°, we have an increase of 29° in 2,000 feet, which is at the rate of 1° in 69 feet.

Mr. Symons has taken a series of observations at the depth of 1,000 feet in the Kentish Town well, with the view of determining whether the temperature changes. The instrument employed is a very large and delicate Phillips' maximum thermometer. The following is a list of the observations:—

Date of lowering.	Depth indicated. Feet.	Thermometer set at.	Date of raising.	Depth indicated. Feet.	Temperature. Fahr.
1874	1000	64·50	May 8	1007	66·82
" May 8	1000	63·80	July 2	1009	(reading lost.)
" July 2	1000	63·20	July 28	1005	67·40
" July 28	1000	65·10	Sept. 8	1004	67·51
" Sept. 8	1000	65·80	Sept. 29	1004	67·43
" Sept. 29	1000	65·81	Oct. 30	1006	67·68
" Oct. 30	1000	63·40	Dec. 3	1006	67·52
" Dec. 3	1000	63·80	Jan. 7	1009	67·63
1875 Jan. 7	1000	63·75	Feb. 1	1006	67·56
" Feb. 1	1000	63·90	March 3	1005	67·58
" March 3	1000	63·90	May 3	1006	67·62
" May 3	1000	63·95	June 1	1005	67·49
" June 1	1000	63·00	July 7	1005	67·53
" July 7	1000	63·87	Aug. 3	1004	67·58
" Aug. 3	1000	63·87	Sept. 10	1004	67·68
" Sept. 10	1000	64·00	Oct. 2	1003	67·58
" Oct. 2	1000	63·90	Oct. 19	1004	67·62
" Oct. 19	1000	63·80	Nov. 1	1005	67·62
" Nov. 1	1000	63·70	Dec. 1	Wire broke.	

The "depth indicated" is shown by a measuring wheel or pulley, over which the wire runs by which the thermometer is raised and lowered, as described, with a diagram, in the Report for 1869. The above table shows that there is always some stretching, real or apparent, in the interval between lowering the thermometer and raising it again. Recent observations by means of a fixed mark on the wire, have shown that the change is not, in the main, a permanent elongation, but an alternation of length. It is probably due in part to the greater tension which the wire is under in raising than in lowering, a circumstance which will cause a temporary difference of length variable with the rapidity of winding up; also in part to the circumstance that the wire is warmer when it has just left the water than when it is about to be let down. Some portion of the irregularity observed may be due to variations of temperature in that part of the well (210 feet) which contains air. The observations, taken as a whole, show that any variations of temperature which occur in this well at the depth of 1,000 feet, are so small as to be comparable with the almost inevitable errors of observation. The observations will be continued at intervals of six months, with additional precautions, and with an excessively slow (specially constructed) non-registering thermometer, in addition to the maximum thermometer hitherto employed.

Through the kindness of the eminent geologist, M. Delesse, of the Ecole Normale at Paris, observations have been obtained from the coal mines of Anzin, in the north of France. They were taken under the direction of M. Marsilly, chief engineer of these mines. Maximum thermometers of the protected Negretti pattern, were inserted in holes bored horizontally to the depth of ·6 or ·7 of a meter in the sides of shafts which were in process of sinking, and in which there was but little circulation of air. A quarter of an hour was allowed to elapse in each case, after the boring of the hole, before the thermometer was inserted, and the hole plugged. Four different shafts were tried. Those designated as Nos. I, II, III, were in the mine Chabaud La Tour; and No. IV was in the mine Renard.

In Shaft I, observations were taken at eight different depths, commencing with the temperature 56½° F. at the depth of 38·5 meters, and ending with 67¾° F. at 200·5 meters.

In Shaft II there were observations at four depths, commencing with 55° at 87·8 m., and ending with 63½° at 185 m.

In Shaft III there were observations at three depths, commencing with 56° at 87·8 m., and ending with 62½° at 144 m.

These three shafts, all belonging to the same mine, were very wet, and the temperature of the air in them was 11° or 12° C. (52° or 54° F.).

In Shaft IV, which was very dry and had an air temperature of about 15° C. (59° F.), observations were taken at six depths, commencing with 70¾° F. at 21·2 m., and ending with 84° F. at 134·8 m.

The mean rates of increase deduced from these observations are:—

In Shaft	I,	1° F. in	14·4 m.,	or in	47·2	feet.
"	II,	"	11·5 m.,	"	37·7	"
"	III,	"	8·65 m.,	"	28·4	"
"	IV,	"	8·57 m.,	"	28·1	"

The observer mentions that in Shaft II there was at the depth of 90 m. a seam of coal, in which heat was generated by oxidation; but no such remark is made with respect to any of the other shafts, although it is obvious that some disturbing cause has rendered the temperatures in shaft IV abnormally high. Possibly the heat generated in boring the holes for the thermometers in this shaft (which was dry) has vitiated the observations, the instruments employed being maximum thermometers. Two of the slow non-registering thermometers mentioned in last year's report have been sent to M. Delesse, to be used for verification.

The slow-action thermometers are constructed on the following plan: The bulb is cylindrical and very strong, and is surrounded by stearine or tallow, which fills up the space between it and a strong glass shield in which the thermometer is inclosed. The shield is not hermetically sealed (not being intended for protection against pressure), but is stopped at the bottom with a cork, so that the thermometer can be taken out and put in again if desired. Stearine and tallow were selected, after trials of several substances, including paraffin-wax, bees' wax, glue, plaster of Paris, pounded glass and cotton wool. The thermometers are inclosed in copper cases lined with india-rubber. When placed, without these cases, in water differing 10° from their own temperature, they take nearly half a minute to alter by one-tenth of a degree.

In concluding this report, your committee desire to express their regret at the losses which they have sustained by the deaths of Professor Phillips, Sir Charles Lyell, and Col. Strange, of whose valuable services they have been deprived within the last three years.

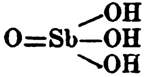
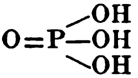
SCIENTIFIC INTELLIGENCE.

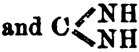
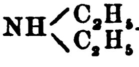
I. CHEMISTRY AND PHYSICS.

1. *On Iodine Trichloride.*—CHRISTOMANOS has described, as an excellent lecture experiment, the preparation of pure iodine trichloride by the action of dry chlorine upon dry hydrogen iodide, the latter gas being conducted into the former in excess. The reaction takes place in two stages: $HI+Cl_2=HCl+ICl$ and $ICl+Cl_2=ICl_3$. At the first contact of the two gases, a transient white dense cloud of hydrogen chloride appears in which float innumerable minute gold-yellow flakes of the trichloride. On increasing the flow of gas, reddish-violet fumes appear and the gas frequently ignites, forming an experiment of great splendor. The walls of the vessel are covered with thick, bright lemon-yellow crystals, which are converted into the monochloride by an excess

of hydrogen iodide, but may be preserved in an atmosphere of chlorine. Iodine trichloride fuses at 32° C., is volatilized at 47·5° (though it gives off vapor even at −12°) and is dissociated at 72° into monochloride and chlorine. It is soluble in cold water without decomposition.—*Ber. Berl. Chem. Ges.*, x, 434, March, 1877.
G. F. B.

2. *On the Atomic Weight of Selenium.*—Petterson and Ehman have redetermined the atomic weight of selenium by several methods, using for analysis calcium selenate, ammonio-aluminum selenate (an alum) magnesium and silver selenites and silver selenate. The numbers obtained not being sufficiently accordant they tried reducing selenous oxide by means of sulphuric acid and determining the selenium precipitated. In five experiments they deduced the atomic weight of selenium as 79·10, 79·06, 79·08, 79·06, 79·08, the mean of which is 79·08, which may be accepted as the true atomic weight of this metalloid.—*Bull. Soc. Chem.*, II, xxvii, March, 1877.
G. F. B.

3. *On Trihydroxylantimonic acid and Antimonyl chloride.*—Analogy points out the existence of an antimonic acid  $O{=}Sb{\begin{smallmatrix}\diagup OH\\ —OH\\ \diagdown OH\end{smallmatrix}}$ and an antimonyl chloride $SbOCl_3$, corresponding respectively to  $O{=}P{\begin{smallmatrix}\diagup OH\\ —OH\\ \diagdown OH\end{smallmatrix}}$ and to $POCl_3$. Daubrawa has studied the question of the antimonic acids anew, using Berzelius's method for preparing them, i. e., by dropping antimonic chloride into water. The results of analysis showed that the air-dried precipitate was $H_8Sb_2O_9$; dried over sulphuric acid, it was H_3SbO_4; at 100° C., it became $H_4Sb_2O_7$; at 200°, $HSbO_3$; at 275°, Sb_2O_5; and above 300°, Sb_2O_4. For the preparation of the oxychloride, one part by weight of water was dropped into sixteen parts by weight of antimonic chloride. A yellowish-white distinctly crystalline mass resulted, which was deliquescent in the air, and which fused, boiled and sublimed in a closed tube, dissociating into SbOCl and Cl_2 at higher temperatures. The analysis, which was difficult, gave the formula $SbOCl_3$.—*Liebig's Ann.*, clxxxvi, 110, March, 1877.
G. F. B.

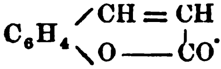
4. *On the Constitution of Cyanamide.*—Of the two rational formulas assigned to cyanamide, $N{\equiv}C{-}NH_2$ and  $C{\begin{smallmatrix}\diagup NH\\ \diagdown NH\end{smallmatrix}}$, the existence of di-silver-cyanamide would seem to fix the latter as the more probable constitution. Fileti and Schiff have proved, however, that this imide formula is actually not the true one. By acting on di-silver-cyanamide with ethyl iodide, di-ethylcyanamide was obtained, identical in properties and in decomposition products with the di-ethylcyanamide obtained by Cloëz, Cannizzaro and Cahours from cyanogen chloride and diethylamine. As in this latter body the two ethyls are united to the same nitrogen atom—since it came from diethylamine  $NH{\begin{smallmatrix}\diagup C_2H_5\\ \diagdown C_2H_5\end{smallmatrix}}$—it

follows that they are in the former; and hence that the rational formula of cyanamide itself is $N\equiv C-NH_2$.—*Ber. Berl. Chem. Ges.*, x, 425, March, 1877. G. F. B.

5. *On Potassium triiodide.*—Johnson has succeeded in obtaining potassium triiodide by evaporating a saturated aqueous or alcoholic solution of iodine in potassium iodide, over sulphuric acid. At first dark colored cubes of the iodide colored by iodine appeared; but after some days, lustrous dark blue prismatic crystals were deposited, sometimes two inches long, which afforded the composition of the tri-iodide on analysis. This substance is very deliquescent, becoming a brown liquid on exposure to the air. Its specific gravity at 15° was 3·498. From the fact that its atomic volume is 120·2, by experiment, and 122·2 by calculation from the sum of the atomic volumes $K+I_3$, but only 105·64 from $KI+I_2$, the author infers that it is an atomic and not a molecular compound.—*J. Ch. Soc.*, xxxi, 249, March, 1877. G. F. B.

6. *On Ethyl-mercaptan and its Derivatives.*—In the course of an extended investigation into ethyl-mercaptan and the corresponding mercaptides, Claesson has made the curious observation that the group $-\cdot-S.C_2H_5$ of mercaptan is readily exchanged for the haloid constituents of the fatty series, the substitution taking place the more readily the less condensed the carbon nucleus of the compound. Thus by acting on carbon tetrachloride with mercaptan in presence of sodium ethylate, sodium chloride separates, the liquid boils from the heat evolved, and a light yellow oil of 1·01 specific gravity is obtained, which the author calls carbon-tetra-mercaptide, and which has the formula $C(S.C_2H_5)_4$. He has prepared also dicarbonhexamercaptide $C_2(S.C_2H_5)_6$ and dicarbontetramercaptide $C_2(S.C_2H_5)_4$. The author has prepared also ethyl-tetrasulphide $(C_2H_5)_2S_4$ and has studied its properties and reactions.—*J. pr. Ch.*, II, xv, 193, March, 1877. G. F. B.

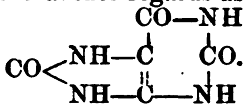
7. *On the Synthesis of Coumarin.*—Tiemann and Herzfeld have effected a new synthesis of coumarin. They were led to the method by observing that acetylparacumaric acid was obtained when paroxybenzaldehyde was heated with acetic oxide and sodium acetate, and that benzaldehyde similarly treated yielded cinnamic acid; from which they inferred that salicylaldehyde (orthoxybenzaldehyde) would yield an acetylorthocumaric acid and so coumarin. The reaction readily took place, and the expected acid was produced, and from it also ortho-cumaric and hydro-orthocumaric (melilotic) acid. By simple heating, acetylorthocumaric acid was decomposed into acetic oxide and acid and coumarin which was obtained pure by recrystallization from ether. The authors consider it a lactide-like anhydride with the formula



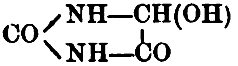
$$C_6H_4\begin{cases}CH=CH\\ O\text{——}CO\end{cases}$$

.—*Ber. Berl. Chem. Ges.*, x, 283, Feb. 1877. G. F. B.

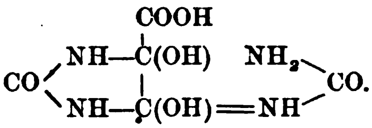
8. *On the Decomposition of Glyoxalyl-urea.*—To test the question whether the substance obtained by protracted boiling of a

solution of uroxanic acid was really glyoxalylurea, as assumed, **Medicus** acted upon it with potassium hydrate, which would split it into urea and glyoxalic acid, and then would decompose the latter into oxalic and acetic acids. The products were examined and proved to be those mentioned. Hence the author regards as proved his formula for uric acid which is 

$$\begin{array}{l}\qquad\qquad\quad\mathrm{CO{-}NH}\\ \mathrm{CO}\!<\!\begin{array}{l}\mathrm{NH{-}\overset{|}{C}}\quad\mathrm{\overset{|}{C}O.}\\ \mathrm{NH{-}\overset{\|}{C}{-}\overset{|}{N}H}\end{array}\end{array}$$

Glyoxalylurea is 

$$\mathrm{CO}\begin{array}{l}\diagup\mathrm{NH{-}CH(OH)}\\ \diagdown\mathrm{NH{-}\overset{|}{C}O}\end{array}$$

and uroxanic acid is 

$$\begin{array}{l}\qquad\qquad\quad\mathrm{COOH}\\ \mathrm{CO}\begin{array}{l}\diagup\mathrm{NH{-}\overset{|}{C}(OH)}\quad\mathrm{NH_2}\diagdown\\ \diagdown\mathrm{NH{-}\overset{|}{C}(OH){=}NH}\diagup\end{array}\mathrm{CO.}\end{array}$$

—*Ber. Berl. Chem. Ges.*, x, 544, April, 1877. G. F. B.

9. *On two new Alkaloids, Strophantine and Ineine.*—**Hardy** and **Gallois** have examined the poison variously known as inaye, onaye, gombi, etc., extracted in Africa from the seeds of *Strophantus hispidus*, a climbing plant belonging to the Apocyneae. Fraser examined this substance and obtained from it an active extract, to the alkaloid in which he gave the name Strophantine. The authors have succeeded in preparing this body crystallized and have shown that it arrests the action of the heart, the ventricles being in systole. From the tufts about the seeds, they have also obtained a second alkaloid which they call ineine.—*Bull. Soc. Ch.*, II, xxvii, 247, March, 1877. G. F. B.

10. *Occurrence of Copper normally in the Blood of Wild Animals.*—**Cloëz**, having to incinerate the blood of a roebuck, killed in the woods, and to analyze the ash, was surprised to detect in it an appreciable quantity of copper. Fearing that it might have entered by accident during his operations, he repeated the analysis on the blood of another buck, taking special precautions. The result was the same, the 530 grams of blood affording three milligrams of copper oxide. It must have existed either in the plants eaten as food by the animal or in the water which he drank.—*Bull. Soc. Ch.*, II, xxvii, 196, March, 1877. G. F. B.

11. *Is Glass impervious to Gases?*—Professor G. **Quincke** has tried to force hydrogen and carbonic acid, by pressures of from 40 to 120 atmospheres, through a glass wall 1·5 mm. in thickness, and to determine by the loss of weight, the quantity of gas that had passed through during seventeen years.

One leg of a V-shaped glass tube was a capillary tube of 200 mms. in length, closed above; the other was a tube contracted in the middle and open above, 150 mms. long, 8 mms. in diameter and 1·5 mms. thick. Into the open leg a drop of quicksilver was put; upon this dilute sulphuric acid was poured; into the upper part some sheet zinc was pushed, which was kept from contact with the acid by the contraction of the tube; and then the open end was carefully closed by fusion at a glass-blower's lamp. Four tubes thus prepared underwent a double weighing; and then, by inclining the tubes, the sulphuric acid was brought into contact with the zinc. The pressure of the hydrogen was shown by the diminution of volume of the air in the capillary tube, which served for a manometer. Its amount on the first day, in the different tubes, was from 1½ to 10 atmospheres, rose in five months up to 27–54 atmosphere and in 17 years up to 25–126 atmospheres. During this time the tubes were frequently doubly weighed on an excellent balance; and exactly the same weight, within from 0·1 to 0·3 of a milligram, was always found.

Another similar tube, with carbonate of lime and concentrated sulphuric acid, in which the pressure of the carbonic acid gas amounted on the first day to 21 atmospheres, after five months to 34 atmospheres, and after 17 years to 44, showed likewise always the same weight of 14·6361 grams.

Thus according to these experiments, a pressure of from 40 to 100 atmospheres cannot, during a space of seventeen years, force through 1·5 mm. thickness of glass a perceptible quantity of hydrogen or carbonic acid.

While at the commencement the concentrated sulphuric acid wetted the glass sides of the tube, and showed a sharp marginal angle (apparently 0°), gradually in the course of years the angle has become obtuse, and the acid flows in the tube with condensed carbonic acid like quicksilver in a glass tube filled with air.

In the atmosphere of hydrogen the angle at the margin of the dilute sulphuric acid, which at first likewise wetted the sides, has also increased to about 60°.

The glass thus appears to have gradually in the course of years, under the influence of the great pressure, become coated with a thin layer of carbonic acid or hydrogen respectively, which exerts a different attraction from that which glass exerts upon the liquid particles at the margin of the surface. A similar film of gas must have been deposited on the surface of the zinc and obstructed the further chemical action of the acid.—*Pogg. Ann.*, clx, 118; *Phil. Mag.*, iii, 314. E. C. P.

12. *Polarization of the Rainbow.*—M. J. DECHANT explains the observations of Schiel and Tyndall that the light of the rainbow could in all cases be extinguished by a Nicols' prism, by Fresnel's formula for the reflection of light. The light falls on the posterior wall of the drop at an angle of 40°, while the angle of total polarization is about 37°. The ratio of the two polarized beams for the red rays is consequently about 24·5 and for the violet rays 34·9. Or, the rainbow is diminished in brightness 25 to 35 fold when the Nicol is rotated 90°. If the index of refraction of the liquid was $\sqrt{2}=1·414$ the polarization would be complete. Calculation shows that for oil of cassia the ratio of the red rays is 6·3 and of the violet 2·8. Forming a rainbow by scattering this liquid in sunlight by an atomizer the light cannot be extinguished by a Nicol prism in any position.—*Pogg. Ann.*, clx, 123. E. C. P.

13. *The Radiometer.*—Two views have been offered as to the mode of action of the gas in the radiometer. One attributes the motion to reaction of gas particles getting heated on the vanes, then dancing off; the other to air currents which are directed toward the plate in consequence of heated air rising from it. M. Neesen has endeavored (Pogg. Ann.) to decide between these views. If the second view is correct, he argued, the wall of the vessel, by becoming also heated, must also acquire influence through rise of heated air from it as from the vanes. If the rotation be merely a phenomenon of reaction there is no reason to suppose such an influence of the fixed wall. Now by giving the radiometer an eccentric position within the glass vessel such an influence of the walls should be readily recognized. He describes a number of experiments made in this way, and which he regards as supporting the second view.

In an article contributed to Poggendorff's Annalen, M. Zöllner is led to take the following positions in reference to the radiometer. The explanation of radiometric motions based on the principles of the mechanical theory of gases, make suppositions about the relation of the mean lengths of path of the gas molecules to the dimensions of the vessel which are not realized in fact. This explanation further leaves out of consideration, without sufficient ground, the simultaneous existence of mercury vapors whose molecules have a more then seven times greater mass and a much smaller mean length of path than the molecules of the gases acting according to the mechanical theory of gases. Hence we are not warranted in regarding the radiometric motion discovered by Crookes as an empirical confirmation of the mechanical theory of gases.—*Nature*, xv, 521. E. C. P.

14. *Fluorescence.*—M. E. Lommel discusses the intensity of the light of fluorescence assuming that the quantity of the light which an element of volume of the fluorescent substance can emit is proportional to the quantity of exciting light which is absorbed. He concludes:

(1.) That with an increasing concentration, the intensity of the fluorescent light at first increases up to a certain minimum, and then decreases.

(2.) That the ratio of the light emitted by a superficial layer of given thickness, to the total fluorescent light, increases with the intensity of the absorption, and is as much more feeble as we observe it at a greater distance.

(3.) That the mixture of colors which constitutes fluorescent light changes with the coefficient of absorption of the exciting light, in such a way that the ratio of the intensities approaches more and more that which characterizes the type of the fluorescent spectrum, to the extent that the exciting rays are capable of being absorbed.

(4.) That the fluorescent light, observed at a great distance, is formed of a mixture of colors in which the rays very largely absorbed are in less proportion than when the observation is made at a small distance.

(5.) That by observing the fluorescence by transparency as Lubarsch has done, the proportion of the rays most absorbed is strongly diminished.

(6.) That it is, on the contrary, as great as possible when, the observation being effected on the side of the incident rays, the angle of incidence is very great.

All these conclusions follow naturally from the first proposition and seem to involve only very natural hypothèses.

This theory demands nothing but that the law of Stokes shall be in general correct. It explains, on the contrary, very well the disagreement of the experiments of Lommel, made under conditions theoretically more favorable than those of his opponents.—*Pogg. Ann.*, clx, 75, *Journ. de Phys.*, vi, 126. E. C. P.

15. *Electricity and the Electric Telegraph;* by Geo. B. Prescott. 978 pp. 8vo, with 564 illustrations. New York. 1877. (D. Appleton & Company.)—This volume, by Mr. Prescott, is a most important contribution to scientific literature, honorable alike to the learning and industry of the author. It is a comprehensive review of the application of electrical principles to telegraphy. It discusses with sufficient thoroughness the laws of electrical resistance and measurement; the determination of voltaic constants; the laws of electro-magnetism; of the measurement of electro-motive force; of galvanic polarization and the application of these and other principles to telegraphic circuits and land lines; the phenomena of charge and discharge on land lines and underground lines; submarine cables; electrostatic induction on telegraph lines; the phenomena of charge in submarine cables; coefficient of charge in submarine and land lines; duration of the variable state when the extremity of the line is to earth, and when it is insulated; the time required to produce a signal; the earth a reservoir of electricity, and its electrical resistance. These topics fill nearly half (415 pages) of the volume; the remainder is occupied with a historical notice of experimental telegraphs of the American and European Morse system, and a full notice of all other systems and instruments, illustrated by very beautiful, original wood-cuts. The discoveries and improvements of late years, especially the duplex and quadruplex modes of transmission, and the improved type printing apparatus, which, as the author says, have in America almost revolutionized the telegraph service, are now for the first time illustrated with a completness worthy of the importance of the subject. The harmonic telegraphs or telephones are also described and illustrated. Mr. Prescott's book is prepared with great care, giving to each investigator and inventor just consideration: and while it is full in its technical detail it is also thorough in its scientific accuracy, qualities rarely combined, and worthy of the electrician of one of the most widely extended telegraphic organizations in existence. B. S.

II. GEOLOGY AND NATURAL HISTORY.

1. *Annual Report on the Geographical Surveys west of the 100th Meridian*, by G. M. WHEELER, 1st Lieut. Eng. U. S. A. 356 pp. 8vo, with many maps and plates. Washington, 1876. —Lieutenant Wheeler's Report, extending to 79 pages, treats of the general results of the expedition. It is followed by appendixes, containing geographical, geological and other information, by Lieut. W. L. MARSHALL, Lieut. E. BERGLAND, Lieut. W. L. CARPENTER, Lieut. R. BIRNIE, Jr., Lieut. C. C. MORRISON, and Lieut. C. W. WHIPPLE; on meteorology and hypsometry by Lieut. W. L. MARSHALL; on the geology and mineralogy of Southeastern California—the alkaline lakes, thermal springs and brackish waters of Southern California—the physical and agricultural features and ethnology of Southern California—the meteorology of the Mohave Desert and the geographical distribution of its vegetation, by Dr. O. LOEW; on the geology of a portion of Southern California by Prof. J. MARCOU; on the geology of the mountain range from La Veta Pass to the head of the Pecos, by A. R. CONKLING; economic botany and agriculture of Southern California, by Dr. J. T. ROTHROCK; on the ornithology and the mammals of portions of California, by H. W. HENSHAW; on Orthoptera, by S. H. SCUDDER; on Coleoptera, by Dr. J. L. LECONTE; on the Alpine insect fauna, by Lieut. W. L. CARPENTER; on eleven idioms spoken in Southern California, Nevada and on the Colorado River, by A. S. GATSCHET.

In the paper by Prof. J. Marcou, the Tertiary beds of Chico Creek, California, are referred to the Eocene Tertiary, instead of Upper Cretaceous, notwithstanding the presence of a few Cretaceous species, as *Ammonites Chicoensis*, and *Baculites Chicoensis*, the species, with these exceptions, having prominently a Tertiary character.

2. *Geological and Geographical Survey of the Territories*, F. V. HAYDEN, U. S. Geologist in charge.—Bulletin No. 2 of vol. III, recently issued contains a paper on Western Diptera, comprising descriptions and new genera and species, by C. R. OSTEN-SACKEN, occupying 165 pages; a report on Insects collected by P. R. Uhler in 1875, and of Hemiptera collected by A. S. Packard, Jr., by P. R. UHLER, with two plates, extending to 120 pages; and descriptions of the Araneæ collected in 1875, by A. S. Packard, Jr., by T. THORELL, over 50 pages. The memoir by P. R. Uhler contains monographs of the families Cydnidæ and Saldæ.

3. *Contributions from the Laboratory of the University of Missouri;* Report by the Curators of the University of Missouri, to the Governor of the State. Includes a paper by Prof. P. Schweitzer on the various methods of separating and determining Barium, Strontium and Calcium; a paper by C. P. Williams on the composition of Missouri leads (in which the lead constitutes 99·91 to 99·993 per cent, and the silver 0·00029 to 0·00615 per

cent); and analyses of Copper ores, Smithsonite from Dade County, etc.

4. *Organogeny of the Female Flower of Gnetum Gnemon. Della Organogenia dei fiori feminei del Gnetum Gnemon* L., *nota di* O. BECCARI. Extr. from *Nuovo Giornale Botanico Italiano*, vol. ix, No. 1. Jan. 1877. With a plate.—Beccari's observations and notes were made at Ternate, in the Moluccas. He was not aware that anything on the subject had then been published in Europe; but in his paper he refers to Griffith as having first asserted that the whole floral apparatus in question belongs to the ovule. Beccari describes the proper female flowers, viz: those of the fertile ament, and distinguishes from them the abortive female flowers which accompany the male ament. The latter have only two envelopes and no embryo-sac; the former have three, and the embryo-sac appears at the time of pollination. The ovule or female flower—whichever it be called—is developed in the axil of an ament-scale, the nature of which is unquestioned; it is sessile, and surrounded by some multicellular "paraphyses." Its body or central part is an ovular nucleus. The question turns upon the nature of the coats. Now these form in succession from without inwards; i. e., the external one is the oldest, and at an early stage is 2-toothed or 2-lobed at apex, as if formed of two confluent parts. Within this appears a second, as a ring or cupule around the base of the nucleus, which in due time it encloses; it shows no indication of a bipartite division or lobing. Soon after this becomes manifest, the third coat originates similarly within the second, advances beyond it and beyond the nucleus, being extended into a styliform tube with a 2-parted apex. This internal and flask-shaped coat is found in the sterile-female flowers of the male ament, but is less prolonged; the external coat equally exists; but the intermediate coat is wanting.

It is taken for granted, on whatever view of the homology, that we have to do with a secondary axis, in the axil of a bract, and that the nucleus is the termination of this axis. According to Griffith the enclosing sacs are coats to the ovule, of which the central body is the nucleus; consequently, this ovule has the anomaly of three integuments. According to Beccari, the nucleus is the whole ovule, viz., an ovule without coats in the manner of that of *Loranthaceæ* and *Santalaceæ*, and the coats are floral organs. A comparison with the quasi-hermaphrodite flowers of *Welwitschia* assures him that the middle and shortest envelope answers to the andrœcium in those flowers, whence it follows that the outer covering is perigonial and homologous with the floral envelope of *Welwitschia*,—only that is tetraphyllous, this is simpler and confluent-diphyllous. It follows also that the innermost sac is carpellary and diphyllous. The gist of the argument in support of this view turns upon these two considerations: 1. *Gnetaceæ* with other Gymnosperms are the lowest type of Phanerogamia; it is most unlikely that such a low type would be provided with such a high type of ovule as one having three coats;

it is more likely that the ovule of *Gnetum* would correspond with the simplified one of *Loranthaceæ*, with which the relationship is not indistinct. 2. The order of evolution of these coverings, i. e., from without inwards or from below upwards, is that of leaves or whorls upon an axis, and of the floral organs in a flower; while ovular coats, as is well known, form in reverse order, the external one latest. The evidence is fairly convincing, and other recent investigations point to the same conclusion.

Some accompanying theoretical deductions drawn by Beccari are not so convincing nor so important. Nor need we share the hesitation with which he uses the name of *Gymnospermæ*. He prefers to continue the term because the ovules, though not destitute of ovary, are destitute of proper ovular coats. But so are not a few angiospermous plants. We should continue it under the original signification, because, admitting the flask-shaped envelop to be homologous with pistil, it is not functionally one; for the pollen reaches and acts directly upon the ovule itself, and not through the intervention of a stigma. Ovules reduced to the nucleus only were not known to Robert Brown, or at least were not considered by him in their present bearing. Being now recognized, the question whether the coat of the seed in *Coniferæ* and *Cycadaceæ* is of carpellary or ovular origin may remain an open one, or may be decided in favor of the former, without essentially derogating from the fitness of the received name for this marked group of orders. Moreover, in flowers so little differentiated as those of *Coniferæ*, the distinction between ovular and carpellary envelopes may be really not cognizable because not yet actual, and so the question may be one of words; while in *Gnetaceæ* an important advance is made, and the ground of a distinction between ovular, carpellary, and perianthial envelopes begins to appear.

If this be so, a vexed question in classification may find a practical settlement. The cultivators of fossil botany, finding that Gymnosperms were far the earliest phænogamous plants, and that no angiospermous Dicotyledons have been detected until long after the appearance of Monocotyledons, almost universally treat the Gymnosperms as a primary division or class of the Vegetable Kingdom. They are seconded by the histologists or organogenists, who naturally make the most of those interesting points of structure which they have brought to view, and which approximate the Gymnosperms to the Vascular Cryptogams. But the question whether Gymnosperms are a part—the earliest and simplest part—of the great class of Dicotyledons, or whether they constitute an independent class or primary group, must be determined by broad and general considerations of the whole structure. Now the transition from *Gnetaceæ* to Angiospermous Dicotyledons is obvious and apparently real. If no transitions are extant between the Gymnosperms and Cryptogams, and if—as is clear—the former are truly Dicotyledonous and exogenous in structure, and have greater affinity with the Angiospermous Dicotyledons than they have with the Monocotyledons, then the taxonomist would appear to have good grounds for concluding that the proper division of the vegetable kingdom is, first into *Phanerogamia* and *Cryptogamia;* then the former into *Monocotyledons* and *Dicotyledons*, then these last into *Gymnosperms* and *Angiosperms*. A. G.

5. *The Paleontological Origin of those trees and shrubs indigenous to the south of France, which are sensitive to Frost in cold winters* (*Sur l'Origine paleontologique, etc.*); by CHARLES MARTINS, 1877, 4to. Extr. from Mém. Acad. Montpellier, tom. ix, pp. 87–122.—Prof. Martins gives a list of 19 of those woody plants which are killed down to the ground by the cold which is occasionally experienced at Montpellier, or on the Mediterranean coast from Peripignan to Mentone, but which spring again from the base and flourish until another exceptional frost occurs. The list ranked in the order of tenderness, begins with the Carob-tree, *Ceratonia siliqua*, and ends with *Vitis vinifera*. With very few exceptions, these plants are solitary representatives in Europe of their genus and tribe; they are represented in a fossil state in the Tertiary formations of S. Europe and also of middle Europe, either by identical species, or by others so similar that they are regarded by paleontologists as equally ancestral. Wherefore, upon a full discussion of the details, it is concluded that these are remains of the Tertiary flora of Europe, which have thus far resisted with success the rigors of a present climate to which they are not completely adapted. A. G.

6. ALEXANDER BRAUN.—We announce with sorrow the death of this excellent botanist, which took place in Berlin, on the 29th of March, after a short illness. Systematic botanists of the first class are everywhere rare, and especially in Germany, where they have gone out of fashion, all attention being turned to histology and the like. In Braun's earlier days there was a goodly array of systematic botanists in Germany: at his decease there are very few of mark, although signs of revival are apparent. Alexander Braun was born at Ratisbon, May 10, 1805, but was brought up at Carlsruhe, where his father became a trusted officer in the post office department. Fifty years ago, there was a knot of closely-allied students at the University of Heidelberg, consisting of Braun, Carl Schimper, Agassiz, and Engelmann. Two of them were transferred to our own soil; the latter is now the sole survivor. Three of them went soon to Munich, where Oken, Schelling, Dollinger, and Martius were teaching; but Braun, Agassiz, and Engelmann met again as fellow-students at Paris in 1832. The first two became allied afterwards by the marriage of Agassiz with Braun's sister. About the time that Dr. Engelmann came to the United States, Braun was made professor of Botany and Zoology in the polytechnic school of Carlsruhe. In 1846 he took the chair of Botany in the University of Freiburg in the Briesgau; was transferred to Giessen in 1850; but in the spring of 1851 was called to Berlin, as the successor to Link and Kunth, taking charge of the Botanic Garden as well as of the professor-

ship. Although he had nearly reached the age of 72, and felt the full weight of his years, yet he was assiduously attending to his official duties when he was suddenly prostrated by acute disease of the chest, terminating fatally. Although learned in almost every department of his science, his *forte*, like that of Agassiz, was morphology, and his systematic work mainly among the higher and some of the lower Cryptogamia, *Marsilia*, *Isoetes*, *Chara*, etc. Although his communications to the scientific journals began as early as the year 1822, when he was only 17 years old, his first contribution to science of much extent, and of high and permanent value, was his memoir on the arrangement of the scales of pine-cones, etc., published in 1830. With this publication began the present knowledge of phyllotaxis. It is well understood that the first steps were taken by his fellow-student, Carl Schimper, and that the early investigations were pursued in common by the two. But Schimper published nothing, or next to nothing, either then or since, although he lived until the year 1867. His name in connexion with the subject is preserved by the favorable mention of his companions and contemporaries; but Braun's treatise was timely and fruitful, and became classical. Braun's ability for the philosophical treatment of vegetable morphology and development was manifested in his next large paper, viz: in his memoir entitled Rejuvenescence in Nature, especially in the life and development of plants. This was first published at Freiburg in 1849–50, and again at Leipsic in 1851, and an English translation of it was published by the Ray Society in 1853. Of a similar character, and marked with equal acuteness, is his essay on The Vegetable Individual in its relation to Species, etc., published in 1853 at Berlin, and which, in a translation by a pupil of mine, was mainly reproduced in this journal (May and Sept., 1855). He reaches the conclusion—which would now be more confidently expressed—"that the individual appears in its full import only in the higher steps of the series of created beings."

In his systematical work, Braun was exceedingly laborious, persevering, and conscientious. When we add that throughout the riper and what should have been the most productive years of his life, he was overtasked with official duties and cares, we shall not wonder that much which he hoped to accomplish is left undone. His work upon *Marsilia*, *Pilularia*, and *Isoetes* may be essentially complete. But his prolonged studies of *Chara*, which began forty years ago, and the completion of which would have crowned his career, have probably not been finished, or brought into such form that the results may be fully secured.

His influence as a teacher is said to have been great; as an investigator he stood in the first rank among the botanists of our time; as a man his simple, earnest, and transparently truthful character won the admiration and love of all who knew him.

A. G.

7. *Notice of Recent Works on Vegetable Paleontology;* by L. LESQUEREUX.—Professor O. HEER has added a fourth volume to his Arctic Flora, a noble supplement to a great and justly celebrated work. The volume contains representatives of the Spitzbergen flora at four epochs of the Carboniferous, the Jurassic, the Cretaceous and the Miocene. It thus affords materials for comparison with those of the same far distant geological times whose floras have become more intimately known from their representatives in the middle part of Europe, and partly, or for the Miocene and the Carboniferous, from those studied from the American continent also.

The first part describes species of the upper Carboniferous of Bell Sound. Even if the stage of the formation, where the plants have been found, is not positively ascertained, the character of these plants point to a more recent deposit than that of Bear Island, described in the second volume of the Arctic Flora. For, out of twenty-six species, it has seven small ferns, *Sphenopteris* and *Adiantites*, a single *Lepidodendron*, one *Stigmaria*, three *Sphenophyllum*, and three *Cordaites*, with a new genus, *Rhynchogonium*, established for beaked fruits clearly related to *Nœggerathia* or *Cordaites*, by its linear ribbon-like striated leaves. One species more than any other, shows the relation of this group of plants to the upper Carboniferous; a *Walchia*, a genus mostly Permian. For there is as yet positive evidence of its presence in the Carboniferous by one species only, in the upper part of the formation in Europe, and none in that of this continent. This small group of Carboniferous plants of Spitzbergen differs in its character from that of Bear Island, which, referable to the Subcarboniferous (the Culm or Mountain Limestone,) separated by Heer in two different periods, has *Calamites radiatus* (*Bornia*), species of *Cardiopteris*, one *Paleopteris*, one *Sphenopteris*, the only plant of a type analogous to the species of Spitzbergen, and the balance, large *Lycopodites*, of the genera *Lepidodendron*, *Knorria*, *Cyclostigma*, *Halonia*, etc., all related to types considered in Europe as representatives of the flora of the Culm and in America of the Subcarboniferous. *Cardiopteris* and *Paleopteris* are of a still more ancient type rarely found in the Subcarboniferous of this country. This division is important as recording for the plants of the Coal in the Arctic regions a distribution analogous to that which is now recognized in the temperate zone of both Europe and America.

The Jurassic flora of Cape Boheman in Spitzbergen, thirty-two species, is supplemented in the same volume by that of the Amour and of Eastern Siberia, eighty-three species, whose analogy with the Jurassic flora of England is marked by sixteen species, and by seven with that of Boheman; a relation showing, as in the Carboniferous flora, an analogous distribution of species in the Arctic and the temperate zones during the Jurassic times. In his introduction, Heer rightly remarks on the importance of the characters of those northern Jurassic types, as putting aside the assertion that as long as we knew nothing of the old floras of the Polar regions, we could not really argue upon the analogy of the floras over a whole continent at a given period of time. From the Carboniferous to the Miocene inclusive the same relation is remarked in the plants of the continent of Europe, and so far as the floras are known, in that of America from the 40th to the 80th degrees of latitude. In tracing analogous or identical types from the Carboniferous flora of Portugal, from the Jurassic of England, from the Miocene of Italy, to those of the same formations of Greenland and Spitzbergen, we can derive reliable conclusions in regard to the characters of the vegetation of these epochs over the whole northern hemisphere, if not over the whole world.

Of the descriptions of the species of these Jurassic plants in the fourth volume of the Arctic Flora, of the perfection of the figures with which they are illustrated, it is not possible to speak with too high commendation. The more common types, that of the *Ginkgo*, of the *Baiera*, while especially represented by numerous figures, are restored in their predominant characters. A new genus, *Czkanowskia*, related to *Trichopitys* of Saporta, has two species exposed in their different organs by two full plates of figures. *Baiera longifolia*, *Ginkgo sybirica* are represented with leaves, flowers and fruits, the fructification of the *Ginkgo* being very similar to the small *Cardiocarpus* of the Coal. One of its species, *Podozamites lanceolatus* is, in its leaves, remarkably similar to the one described as *Pterophyllum? Haydenii* in the Cretaceous flora of Nebraska.

A few vegetable remains of the Cretaceous of Cape Staratschin, already mostly known as described in a former volume, constitute the third part, a very short one, of three pages and half a plate of figures.

The fourth part is a supplementary description of seventy-one Miocene species of three different localities of Spitzbergen: Cape Lyell, the Scott Glacier, and Cape Heer. The relation between the plants of these localities is indicated by a comparatively large number of species, thirty-four being common to Cape Lyell and Scott Glacier, and seven found also at Cape Heer, which has only fifteen species for its flora. Considering the whole group altogether we find it related to the Greenland Miocene flora by twenty species, to that of Alaska and Sitka by eleven, five of which are also present in Greenland; to that of Europe by twenty-one, and to that of the Upper Lignitic of the Rocky Mountains, the Carbon and the Green River groups, by seven. This relation is more than sufficiently close to prove contemporaniety of the formation, even with the North American Miocene, though the number of identical species may appear small. It is even more evident than with the European Miocene; for the Tertiary flora of this last continent is now known by more than four thousand species, while, including even the Lower Lignitic Eocene, we know scarcely as many hundred from the North American Tertiary formations. Therefore the conclusions taken in considering the distribution of the Carboniferous and Jurassic floras are valid in the same degree for the Miocene. The essential types of the vegetation of this epoch are the same over the whole northern hemisphere, modified, however, by a difference already remarked in the climatic circumstances of regions under distant latitudes. For the Spitzbergen Miocene flora has no species of Ficus, nor any kind of Laurineæ. It has, however, two Magnolias representing, probably, the highest degree of temperature of the Arctic of that epoch, equivalent to that at the present time of the middle States of North America, South Pennsylvania, and Ohio, for example, while the Tertiary flora of the Western Territories, Colorado, and Wyoming, has from the Eocene to the upper group, the Pliocene of California, representatives of species now inhabiting the shores Gulf of Mexico, and extending even as far south as Cuba and New Mexico.

The description of eight species from Disco, with two plates of illustrations, closes this fourth part of the Arctic Flora. The species are mostly referable to Jurassic types.

The volume under consideration has been prepared from specimens collected by the Swedish Polar expeditions in the years 1872 and 1873. These specimens were examined by Heer and described in 1874; but the publication of the work then ready has been delayed by circumstances independent of the author's control. In the meanwhile, the celebrated Professor has undertaken the preparation of the floras of the different geological formations of Switzerland, beginning with that of the Carboniferous, just published.* The second part, that of the Jurassic, is complete also, and ready to appear. The Carboniferous flora represents the plants of the Anthracite of Vallais, a formation of very limited extent. The general character of these plants is that of the Upper Carboniferous, marked mostly, at least, by a preponderance of ferns: *Sphenopteris*, *Neuropteris*, *Cyatheites*, *Pecopteris*, etc.; the *Calamariæ* and the *Cordaites*, which the author considers as Conifers. A number of species of *Lepidodendron* and *Sigillaria* are still in this group; and as it has also *Sphenopteris latifolia*, *trifoliata*, etc., the large *Alethopteris*, *A. nervosa*, *Serlii*, *muricata*, *Pluckneti*, which in our Coal measures are more abundant in the middle group or above the Millstone grit, the general facies of this Anthracite flora, judging from the American point of view, is rather that of the middle than of the upper Carboniferous. But it has one species of *Walchia* which, together with some ferns, *Pecopteris arborescens*, *Neuropteris Loschii*, etc., are mostly abundant in the upper Coal measures, even passing to the Permian, and therefore the conclusions of the author on the age of the formation have part of the evidence in their favor. A peculiar trait, marking the vegetable remains of the Anthracite of Switzerland, is the presence, upon the surface of the leaflets of ferns especially, of a coating of very hard carbonaceous matter, nearly transformed into graphite, which generally obliterates the nervation, and the deformation of these pinnules which are often drawn and elongated on one side of the pinnæ while they are contracted or shortened and enlarged on the other. The fossil plants of Rhode Island present exactly the same appearance, the dimorphism of the ferns being there still far more distinctly marked than in the species figured by Heer, and the nervation rendered quite as obscure by the superposition of the coating of hard coaly matter, apparently a transformation of the epidermis by heat. I have tried to explain the deformation of the ferns, as a result of a slow movement of upheaval in successive undulations of the strata as it is remarked along the beach of Newport; a movement which, while the plants were still in a soft state, caused an extension or traction to one side, and therefore this peculiar deformation of the leaflets when placed on one side of the line of the force of upheaval. Another remarkable coincidence is, that *Neuropteris alpina* St., a very rare species, found in Europe only in the anthracite of Switzerland, is found also at Newport, and has not been until recently seen anywhere else in the American Coal-measures. The Carboniferous flora of Heer contains descriptions and figures of one hundred species, seventeen of which are considered as new by the author.

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* Flora fossilis Helvetiæ. Erste Lieferung. Die Steinkohlenflora. Zurich. 1876. T. Wurster & Co.

Professor Heer has, it seems, opportunity to study plants of most of the geological formations of Europe, and indeed his profound knowledge of fossil botany seems to render every work related to this science an easy task for him. He has also recently published a pamphlet on some Permian plants of Hungary,* and there describes one species of *Baiera*, one of *Ulmannia*, two *Voltzia*, one *Schizolepis*, with six *Carpolithes;* these all new species. The work exposed in this short review, and which scarcely represents two years of the labors of the celebrated professor, would make an honorable record for a whole scientific life.

Another European paleontologist, Count Saporta of Aix, enjoying a degree of celebrity as high and as well merited as that of Professor Heer, and equally versed in the study of the fossil plants of the different formations of Europe, has lately with the assistance of his friend, Dr. Marion, published the Pliocene flora of Maximieux. By the exposition of transitional forms traced to living species of the same country, this flora is like a link between the vegetation of the Miocene and that of the present time, and thus affords evidence on the succession and modification of vegetable types which has not been obtained elsewhere until now. The work† describes thirty-two species splendidly illustrated, most of the figures having in contraposition a representation of the living species to which they are compared as identical or intimately related. The exhibition of this relation gives subjects for consideration as instructive to American as to European botanists, if not more so. We find in it a species of *Torreya*, a genus out of Europe now, but present in California; *Platanus aceroides* var. *cuneifolia* intimately related to, if not identical with the North American *Platanus occidentalis*, var. *acerifolia*. *Liquidambar Europeum*, a Miocene species without relation now in the European flora, but reproduced still in that of our continent; in the family of the Laurineæ the group of Maximieux has *Persea Carolinensis;* in the *Magnolia*, a species similar to the American *M. grandifolia;* and still more, one *Lyriodendron*, a *Tilia* represented now by our *T. pubescens*, and an *Ilex* related to *I. Cassine*. Thus, nine species of this group of thirty-two Pliocene European species belong by identity or close affinity to the present North American flora, while ten only are European; the others being related by nine species to the flora of the Canary Islands and by four to Asiatic types.

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* Ueber Permische Pflanzen von Fünfkirchen in Ungarn, von Dr. Oswald Heer. Budapert, (1876.)

† Recherches sur les végétaux fossiles de Maximieux par le Comte G. de Saporta et le Dr. A. F. Marion. Lyon, etc. (1876.)

Besides its intrinsic value, Saporta's work has a peculiar interest for the paleontology of this continent, where only, after Maximieux, materials pertaining to a pliocene vegetation have been obtained; first from the Chalk Bluffs of the Mississippi, below the mouth of the Ohio, and later and more abundantly from the gold-bearing gravel beds of Nevada County, California. From this last formation fifty species are known, and ten from the former; and of these sixty species, forty-six are American, either identical with or closely allied to some species of our present flora. Of the number, six are already represented in the Lignitic flora of the Rocky Mountains, a fact proving the long continuance of vegetable types on this continent; for the American types of the Pliocene of Maximieux, *Platanus*, *Liquidambar*, *Persea*, *Magnolia*, *Lyriodendron*, etc., are all already present in the American Miocene as in that of Europe, and therefore have not come to us by migration. This subject, however, of transformation and migration of vegetable types is examined with some more details in a memoir on the Pliocene flora of California, now in the way of publication as a new volume on the Geology of California, by Professor J. D. Whitney. It is, therefore, more appropriate to postpone a consideration of it for the present.

8. *Preliminary Note on the Development of Organisms in Organic Infusions;* by JOHN TYNDALL, F.R.S. Received January 18, 1877.—I beg leave to submit to the Royal Society a brief preliminary note of the results obtained in the further prosecution of my researches "On the Optical Deportment of the Atmosphere, with reference to Putrefaction and Infection."

The very remarkable experiments of Dr. Roberts, of Manchester, which have been confirmed by Professor Cohn, of Breslau, have been both verified and contradicted by my recent researches. In some cases alkalized hay-infusions have been completely sterilized by boiling for five minutes, in other cases they have withstood the boiling temperature for a far longer period.

Pursuing with scrupulous exactness the method of experiment devised by Dr. Roberts, and in part followed by Professor Cohn, I have found in other infusions than hay an enormous resistance to sterilization. A single conspicuous example will serve as an illustration. Cucumber-infusion has been subjected, for intervals varying from five minutes to five hours and a half, to the boiling temperature without losing its power of developing life. Two days' exposure to a temperature of 90° Fahr., subsequent to this treatment, sufficed to develop in it swarms of *Bacteria.*

The infusion which thus withstood, in one of Dr. Roberts's "plugged bulbs," the temperature of boiling water for 330 minutes, was completely sterilized in three minutes by boiling it in a small flask with a narrow neck, and hermetically sealing the flask during ebullition. In the case of the "plugged bulbs" the observed resistance was due, not to the germs of the infusion, but to those diffused in the air above it.

I have also pursued my experiments with closed chambers, from which the floating matter was removed by self-subsidence. With certain new infusions introduced into this inquiry failure after failure occurred, two or three days generally sufficing to fill the boiled and protected liquids with Bacterial life. The vegetable infusions usually became turbid throughout; but a characteristic feature of the life developed in all infusions during the last three months was the formation upon their surfaces of a thick and deeply pitted fatty scum. Precautions far greater than those found successful a year ago failed to protect these infusions from contamination.

I resorted to the mode of calcination by an incandescent platinum wire, applied with such uniform success in my last inquiry. The wire was brought close to its point of fusion, the period of incandescence was doubled, and extraordinary care was taken to ward off infection by a ring of cotton-wool. The care proved nugatory; for, in despite of it, swarming life appeared in the infusions afterwards.

I tried to reproduce the results with animal infusions obtained with such ease and certainty a year ago. Some of these old infusions, highly concentrated by evaporation, remain with me to the present hour; they are as clear as distilled water. But in my recent experiments, where the care bestowed far exceeded that found necessary in my last inquiry, the animal infusions, like the vegetable ones, fell, for the most part, into putrefaction.

With hermetically sealed flasks, properly boiled and sealed with due care (I would emphasize this condition), there was no difficulty in sterilizing any of the animal infusions.

By the scrupulous removal of every possible source of contamination I was able finally to maintain some of the most refractory of the liquids operated on perfectly pellucid, in closed chambers from which the floating dust had disappeared by self-subsidence.

It is to be noted that the earliest experiments of this inquiry were quite in harmony with all the results of the former one, and that it was only as time advanced that the singular discordance between recent and former results showed itself in any marked degree. What was the cause of this discordance?

The question is to be answered by reference to the experiments with hay-infusions, which were begun early and were multiplied and varied later on. By practice such a mastery over these infusions was at length attained that, though the same method of experiment was undeviatingly pursued, I could contradict or corroborate, at will, the observations of Dr. Roberts and Professor Cohn.

On analyzing these apparently irreconcilable results, it was found that, in almost every case where five minutes' boiling sufficed to sterilize alkalized hay-infusion, the hay employed was mown in 1876, while in almost every case where the greater resistance to sterilization was shown, the hay was mown either in 1875 or some previous year. The hay found most difficult to sterilize was from Colchester, and it was five years old.

To the drying and hardening of the germs of the old hay by time I ascribe this singular result.

An experiment on artificially dried peas, as compared with the same peas undried, is not without instruction. After boiling for an hour or so, the undried peas become tasteless, while the dried ones retained a considerable amount of flavor. After a couple of hours' boiling the undried peas rendered the water in which they were immersed thickly turbid, the liquid surrounding the dried peas remaining at the same time perfectly clear. The dried peas were rendered soft, but many of the green peas were reduced by two hours' boiling to a mere pulp, the mixture of which with the water rendered it muddy.

The comparative tastelessness of the undried peas proved that their juices, which are an essential factor of their individuality, and probably also of their power of germination, had diffused into the surrounding water. On the other hand, the clearness of the water which embraced the dried peas indicated a restriction of the exchange of matter between the peas and the medium in which they were immersed. The experiment threw light upon the fact that even with four or five hours' digesting, it was impossible to make the specific gravity of the samples of my oldest hay sensibly greater than that of water. The dryness and induration of the old hay thus indicated being shared by the germs attached to the hay, endowed them, I doubt not, with their greater power of resistance.

Experiments have also been made with new hay dried artificially at temperatures varying from 140° to 185° Fahr., an account of which shall be communicated in due time to the Royal Society.

The different samples of hay employed in this investigation were introduced in succession into the laboratory of the Royal Institution, and they ended by rendering the atmosphere of the place so virulently infective that precautions which, under ordinary circumstances, were more than sufficient to secure perfect immunity from external contamination, were found utterly ineffectual.

Thanks to the friendly action of the President of the Royal Society, I was enabled to escape from this atmosphere to a purer air. I had a series of tin chambers constructed, which were not permitted to enter the Royal Institution at all, but were taken straight from the tinman to Kew Gardens. They were mounted in the excellent laboratory recently erected there by the munificence of Mr. Jodrell. In this new position the insuperable difficulties encountered in London disappeared, and the experiments followed the course of those described in my last investigation. Two of the chambers gave way; but on being scrutinized they were found leaky. Five sound chambers, on the contrary, remained perfectly intact, and they embraced the particular substances which had given me so much trouble in London. Infusions exposed to the common air at Kew became rapidly rotten.

A fuller account of these researches shall soon be submitted to the Royal Society. In prosecuting them thus far I have been very ably assisted by Mr. Cottrell and his junior colleague Mr. Frank Valter.—*Proc. Roy. Soc.*, vol. xxv, No. 177.

9. *On Heat as a Germicide when discontinuously applied;* by JOHN TYNDALL, F.R.S. Received Feb. 14, 1877. (Letter addressed to T. H. Huxley, Esq., Sec. R. Soc., and dated Feb. 14, 1877.)—In my "Preliminary Note," communicated to the Royal Society on the 18th of January, various infusions were referred to as manifesting an astonishing resistance to sterilization by heat. This resistance was traced to its source; and I have been since informed that you were good enough to express at the time a very favorable opinion as to the significance and value of the results indicated.

It will, I think, now interest you to learn that the most obstinate of the infusions referred to in the "Note" have been since rendered tractable by the application of very simple means. Following up the plain suggestions of the germ theory, I have been able, even in the midst of a virulently infective atmosphere, to sterilize all the infusions by a temperature lower than that of boiling water.

It is known that the prolonged application of a low temperature is often equivalent to the brief application of a higher one: and you may therefore be disposed to conclude that in the experiments here referred to I have substituted time for intensity. This, however, is not the case. The result depends solely upon the manner in which the heat is applied. For example, I boil an infusion for fifteen minutes, expose it to a temperature of 90° Fahr., and find it twenty-four hours afterward swarming with life. I submit a second sample of the same infusion to a temperature lower than that of boiling water for five minutes, and it is rendered permanently barren.

The secret of success here is an open one. I have already referred to the period of latency which precedes the clouding of infusions with visible *Bacteria*. During this period the germs are being prepared for their emergence into the finished organism. They reach the end of this period of preparation successively—the period of latency of any germ depending upon its condition as regards dryness and induration. This, then, is my mode of proceeding: before the latent period of any of the germs has been completed (say a few hours after the preparation of the infusion), I subject for a brief interval to a temperature which may be under that of boiling water. Such softened and vivified germs as are on the point of passing into active life are thereby killed; others not yet softened remain intact. I repeat this process well within the interval necessary for the most advanced of those others to finish their period of latency. The number of undestroyed germs is further diminished by this second heating. After a number of repetitions, which varies with the character of the germs, the infusion, however obstinate, is completely sterilized.

The periods of heating need not exceed a fraction of a minute in duration. Sum them up in the case of an infusion which they have perfectly sterilized; they amount altogether to, say, five minutes. Boil another sample of the same infusion continuously for fifteen or even sixty minutes, you fail to sterilize it, although the temperature is higher and its time of application more than tenfold that which, discontinuously applied, infallibly produces barrenness.

In a few weeks I hope to bring this entire subject under the notice of the Royal Society.—*Proc. Roy. Soc.*, Feb. 1, 1877, vol. xxv, No. 178, p. 569.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *National Academy of Sciences.*—At the session of the National Academy, held in Washington, April 17–20, 1877, the following new members were elected: Elliott Coues, U. S. A., Washington, D. C.; John W. Draper, New York; Henry Draper, New York; S. H. Scudder, Cambridge, Mass.; C. S. Peirce, Cambridge, Mass.

The following is a list of the papers read at the meeting:

On a new measuring instrument: the vernier microscope; by A. M. MAYER.

On the laws ruling the vibration of tuning-forks; by A. M. MAYER.

On the determination of the coefficient of expansion of solids; by A. M. MAYER.

On some remarkable facts in the distribution of magnetism in very long (5 ft. ½ in.) magnets; by A. M. MAYER.

On systematic errors in star declinations; by E. C. PICKERING and W. A. ROGERS.

Micrometer-level and topographical camera; by E. C. PICKERING.

On the young stages of some osseous fishes; by ALEX. AGASSIZ.

The results of deep-sea dredgings; by ALEX. AGASSIZ.

On critical periods in the history of the earth, and their relations to evolution, and on the Quaternary as such a period; by JOSEPH LECONTE.

On the structure of the crystalline lens, and its relation to periscopism; by JOSEPH LECONTE.

On the progressive motion of storms; by WILLIAM FERREL.

Contribution to Meteorology; by ELIAS LOOMIS. (7th paper.)

Improved method of obtaining metallic spectra; by G. F. BARKER.

On the effect produced by mixing white with colored light; by O. N. ROOD.

On Newton's use of the term *indigo* with reference to the color of the spectrum; by O. N. ROOD.

Internal structure of the earth as affecting the phenomena of precession and nutation: supplementary to article under this head read before the Academy, and published in vol. xiii, Smithsonian Contributions; by J. G. BARNARD.

A proposed new method in solar spectrum analysis; by S. P. LANGLEY.
On some researches in the theory of invarients; by J. J. SYLVESTER.
Peculiarities noticed in the oxidation of aromatic sulpho-acids; by IRA REMSEN.
On complex inorganic acids; by WOLCOTT GIBBS.
Description of a detached gravity escapement; by C. A. YOUNG.
Remarks on the apparent secular acceleration of the mean motion of the moon, as derived from the observations of the ancient eclipses; by SIMON NEWCOMB.
Researches in linear theory; by GEO. W. HILL.
On the structure of the "Henry" Mountains; by G. K. GILBERT.
On the public domain; by J. M. POWELL.
Remarks on some artesian wells, along the line of the Union Pacific Railroad in Wyoming Territory; by F. V. HAYDEN.

2. *Excrementitious deposits in the Rocky Mountain region.*—A paper on these deposits, in Nevada, by H. W. HENSHAW (Proc. Acad. Sci. Philad., 1877, 39) sustains the view of Prof. Cope, that they were made by the big-eared rats, a species of *Neotoma*, and probably *N. cinerea.* They consist of vegetable matter, as shown by the chemical analysis of Dr. Lœw, in the volume on Zoology, of Lieutenant Wheeler's expedition. Part have a bitumen-like look, and others vary from this to pill-like excrements. In a crevice of the rocks one deposit had a depth of two feet, and contained also small twigs and some birds' feathers. "The mass was evidently the accumulation of years, and had served as a nest. Throughout was a large amount of hard droppings from which the urine had passed, and whose nature was unmistakable. The urine, charged with a certain amount of excrementitious matters, had filtered through to form the singular deposits." Water or the urine has carried the portions it could dissolve down the faces of walls and deposited it on shelves where no animals without wings could reach, and sometimes on the roofs of cavities. All the regions where these deposits occur are inhabited by the *Neotoma*, which is eminently a vegetarian.

3. *Fourth Annual Report of the New Jersey State Board of Agriculture for the year* 1876. 196 pp. 8vo. Trenton, N. J.—Besides details of economical importance, this Report contains an account of the Green sand beds of the State by Prof. G. H. Cook (Secretary of the Board) with sections, and detailed descriptions, and many analyses of the green sand and clayey marls. All belong to the Cretaceous, excepting the upper layer of the Upper Green sand, which is Eocene Tertiary. The value of the green sand marl, in agriculture, is treated of at length. There is also an account of the Miocene Tertiary marls of the State.

4. *Primer of Chemistry, including analysis;* by A. VACHER. 108 pp. 12mo. London, 1877. (Churchill).—The author states that this little book represents ten years' experience in teaching the rudiments of chemistry and analysis. The term *unit* replaces *atom* and *molecule*, and *antimetal* serves in place of *radical*, and the student is left to guess at the meaning of atomic weight and equivalent, these terms not being found in the book. The science is compressed into a small compass, but the condensation passes the limit of clearness. B. S.

5. *Correction.*—Comet b, 1877, was discovered by WINNECKE.

INDEX TO VOLUME XIII.*

A

Academy, National, April, 1877, 481.
Adams, *A. L.*, saurian vertebra from the Arctic regions, 316.
Agassiz. *A.*, echinoderms of "Porcupine" and "Challenger" expeditions, 164.
zoology of "Challenger" expedition, 165.
Akestorides, action of fuming nitric acid on coal gas, 301.
Allantoin, synthesis of, 218.
Allen, J. A., American Bison, 75.
Aluminium in steel and iron, *Blair*, 421.
Aniline manufacture, *Jackson*, 449.
Areschoug, *J. E.*, Copulation of Microzoospores, 164.
Arnott, N., Elements of Physics, 244.
Astronomical myths, 404.
publications, Lord Lindsay, 398.
Atlantic, shoal in, 326.
Atmosphere of Rocky Mts., *Draper*, 89.
Auerbach, vowel "clang," 378.
Austen, *P. T.*, dinitroparadibrombenzols, 95.
nitro-derivatives of diphenylamine, 279.
nitrogen compounds, noticed, 58.
Aymonnet, properties of chemical substances, 217.
diathermaneity of metals and paper, 303.

B

Baillon, H., Dictionnaire de Botanique, 320.
Balance-beams, rock crystal for, 216.
Barker, *G. F.*, chemical abstracts, 55, 146, 216, 299, 371, 461.
Barrett, *S. T.*, Lower Helderberg of Port Jervis, N. Y., 385.
Becquerel, *E.*, ultra red spectrum, 379.
Belt, *T.*, loess of Rhine and Danube, 383.
Benzol compounds, *Austen*, 95.
derivatives of, 375.
Berthelot, constitution of phosphates, 56.
detection of ordinary alcohol in wood spirit, 218.
chemical actions of the silent electric discharge, 371.
action of ozone on nitrogen, 372.
Berthoud, *E. S.*, meteorology of Golden, Colorado, 326.
Bianconi, plasticity of ice, 59.
Binocular phenomena, *LeConte*, 252.
Blair, *A. A.*, chromium and aluminium in steel and iron, 421.
Blake, J. F., astronomical myths, 404.
Blaserna, P., sound in relation to music, 168.
Boguski, velocity of chemical reactions, 299.
Boisbaudran, properties of gallium, 59.
Boltzmann, kinetic theory of gases, 378.
Boricky, E., igneous rocks of Bohemia, 162.
Boron, so-called crystallized, *Hampe*, 55.
BOTANY—
Dextrorse and sinistrorse, 236, 391.
Elliott's Botany, 81, 392.
European flora, geographical statistics of, 83.
Fertilization, cross- and self-, 125.
France, tender trees and shrubs of, 471.
Fungi, recent papers on, 322.
Gelsemium sempervirens, 58.
Gnetum gnemon, female flower of, 469.
Helianthus tuberosus, 347.
Homogone and heterogone flowers, *Gray*, 82.
Maize fodder, *Johnson*, 202.
Microzoöspores, conjugation of, 164.
Mistletoe, 238.
destruction of trees by, 322.
Monocotyledons, 394.
Onion smut, *Farlow*, 392.
Orchids, fertilization of, noticed, 395.
Sugar beet, alcohol from leaves of, 218.
Sweet Potato, *Johnson*, 197.
Tendrils, coiling of, 391. Williams, 84.
Ulothrix zonata, reproduction of, 163.
Vegetation, *Gilbert*, 20, 99, 181.
See also under GEOLOGY.
Bressa Prize, Turin Acad. Sci., 167.
Broadhead, *G. C.*, barite and göthite from Missouri, 419.
Buffalo Soc. Nat. Sci, Bulletin of, 325.

C

Cailletet, *L.*, measurement of high pressures, 303.
California State Geological Society, 326.
Carbon dioxide, 56.
Carbon, in luminous flames, 217.

---

* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

Carpenter, *W. B.*, physical investigations on the "Valorous," 437.
Challenger expedition, zoology of, 165.
Chamberlain, T. C., geological survey of Wisconsin, 230.
Chapman, E. J., Geology of Canada, 81.
Chemical reactions, velocity of, 299.
Chemistry and physics in America, 61.
Chemist's manual, 404.
Chester, *A. H.*, identity of peganite, variscite and callainite, 295.
  sepiolite from Utah, 296.
Chittenden, *R. H.*, flesh of halibut, 123.
Christomanos, iodine trichloride, 461.
Chromium in steel and iron, *Blair*, 421.
Chronometers, compensation in, *James*, 113.
Claesson, ethyl-mercaptan, 463.
Clarke, *F. W.*, notes on mineral analysis, fluorides, molecular volumes, 290.
Clayden, spectra of indium, 57.
Cleve, two new dichlornaphthalenes, 148.
Cloëz, copper in blood of wild animals, 464.
Coffin, *J. H.*, winds of the globe, 273.
Color, sensation of, *Peirce*, 247.
Columbic acid minerals, *Smith*, 359.
Combustion, increase of weight by, 304.
  influence of pressure on, 220.
Comets in 1877, 399, 400, 482.
Conrad, *T. A.*, relations of Balanus Estrellanus of California Miocene, 156.
Cook, G. H., report of the state geologist of New Jersey, 231.
Cooke, *J. P.*, *Jr.*, new mode of manipulating hydric sulphide, 427.
Cope, *E. D.*, fossil vertebrates from Montana, 316.
Copper in blood of wild animals, 464.
Coumarin, synthesis of, 463.
Crommydis, glycollic acid, 302.
Crow, hypovanadic oxide and its compounds, 147.
Crozier, *E. S.*, destruction of forest trees by mistletoe, 322.
Cyanamide, constitution of, 462.
Cygnus, new star in, 395.

D

Dana, *E. S.*, mineralogical notes, 162, 318.
  text-book of Mineralogy, 317.
Dana, *J. D.*, note on the glacial era, 79.
  A. Wing's discoveries in Vermont geology, 332, 405.
Darwin, C., fertilization of orchids, 395.
  cross- and self-fertilization, 125.
Darwin, *G. H.*, influence of geological changes on the earth's axis, 444.
Dawson, G. M., locusts in Manitoba, 1875, 401.
De Candolle, coiling of tendrils, 391.
Dechant, polarization of the rainbow, 465.
Delafontaine, hermannolite and samarskite, 390.
Delesse, Revue de Géologie, 315.
Diller, *J. S.*, Westfield during the Champlain period, 262.
Diphenylamine, derivatives of, *Austen*, 279.
Dodel, *A.*, Ulothrix zonata, 163.
Draper, *H.*, astronomical observations on atmosphere of Rocky Mountains, 89.
  spectra of Venus and α Lyræ, 95.
Draper, *J. W.*, Chemistry and Physics in America, 61.
  researches in Physics, 67.

E

Ekman, atomic weight of selenium, 462.
Electric discharge, chemical actions of, 371.
Electricity, velocity of, 60.
Elsaesser, evolution of hydrogen in electrolysis, 217.
Emodin from bark of buckthorn, 148.
Engineer's report, 1876, 402.
Ethyl-mercaptan and its derivatives, 463.
Everett, underground temperatures, 452.

F

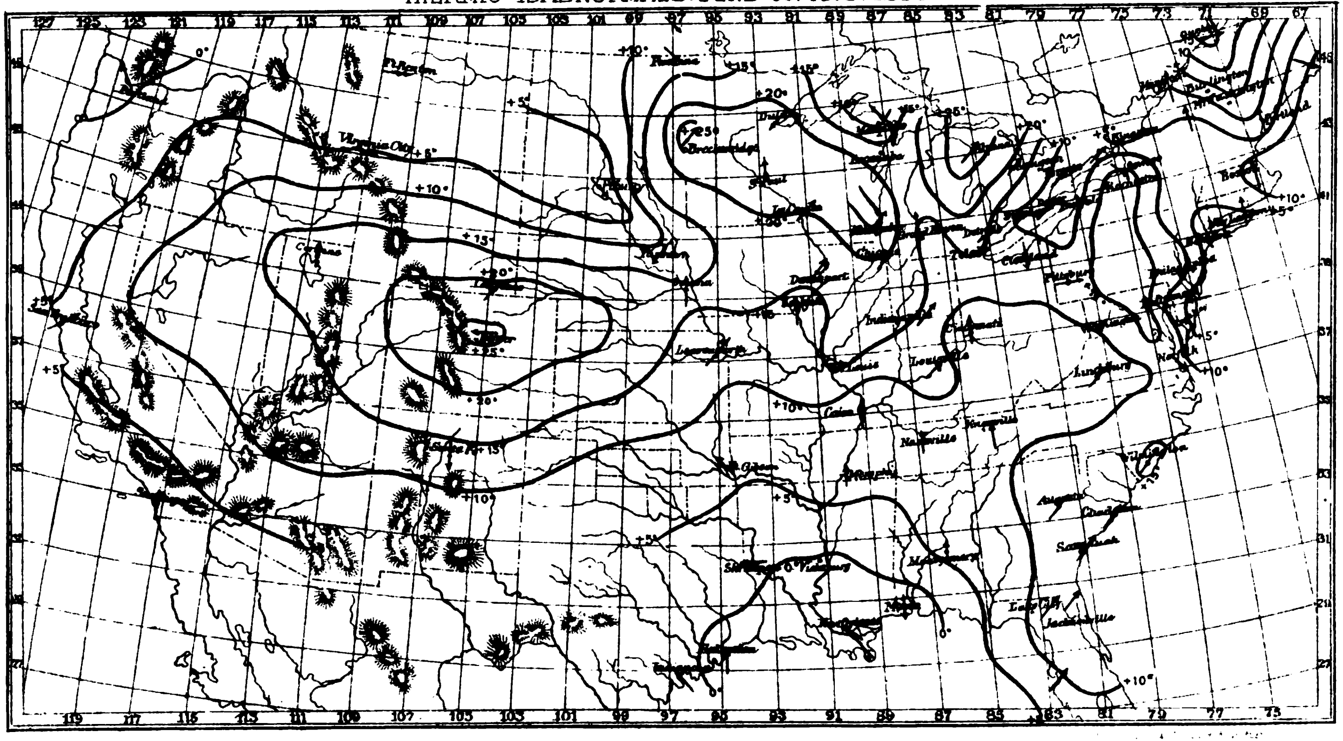
Farlow, *W. G.*, botanical notices, 163, 322.
  onion-smut, 392.
Fat-extraction, *Johnson*, 196.
Fileti, constitution of cyanamide, 462.
Films, metallic, *Wright*, 49.
  of water, 151.
Fischer, phthaleins of tertiary aromatic bases, 149.
Flames, luminous, theory of, 217, 220.
  sensitive, 219.
Fluorescence, 380, 466.
Fluorides, note on, *Clarke*, 291.
Fog-signals, *Henry*, 151.
Fontaine, *W. M.*, vespertine strata of Virginia, 37, 115.
Ford, *S. W.*, Microdiscus speciosus, 141.
  embryonic forms of trilobites, 265.
Forest and prairie regions, origin of, 81.
Friction, laws of, *Kimball*, 353.

G

Gallium, physical properties of, 59.
Galloi, scrophantine and ineine, 464.
Gardner, J. T., topographical survey of the State of New York, 244.
Gases, kinetic theory of, 378.
Geikie, J., Great Ice Age, 81.
Geinitz, H. B., geology and paleontology of the Argentine Republic, 233.
Genth, F. A., Report on the Mineralogy of Pennsylvania, 317.

PLATE I

THERMIC ISABNORMALS. JUNE 18. 1873. 4.35 P.M.



ISOBARIC CURVES. JUNE 18. 1873. 4.35 P.M. PLATE II.

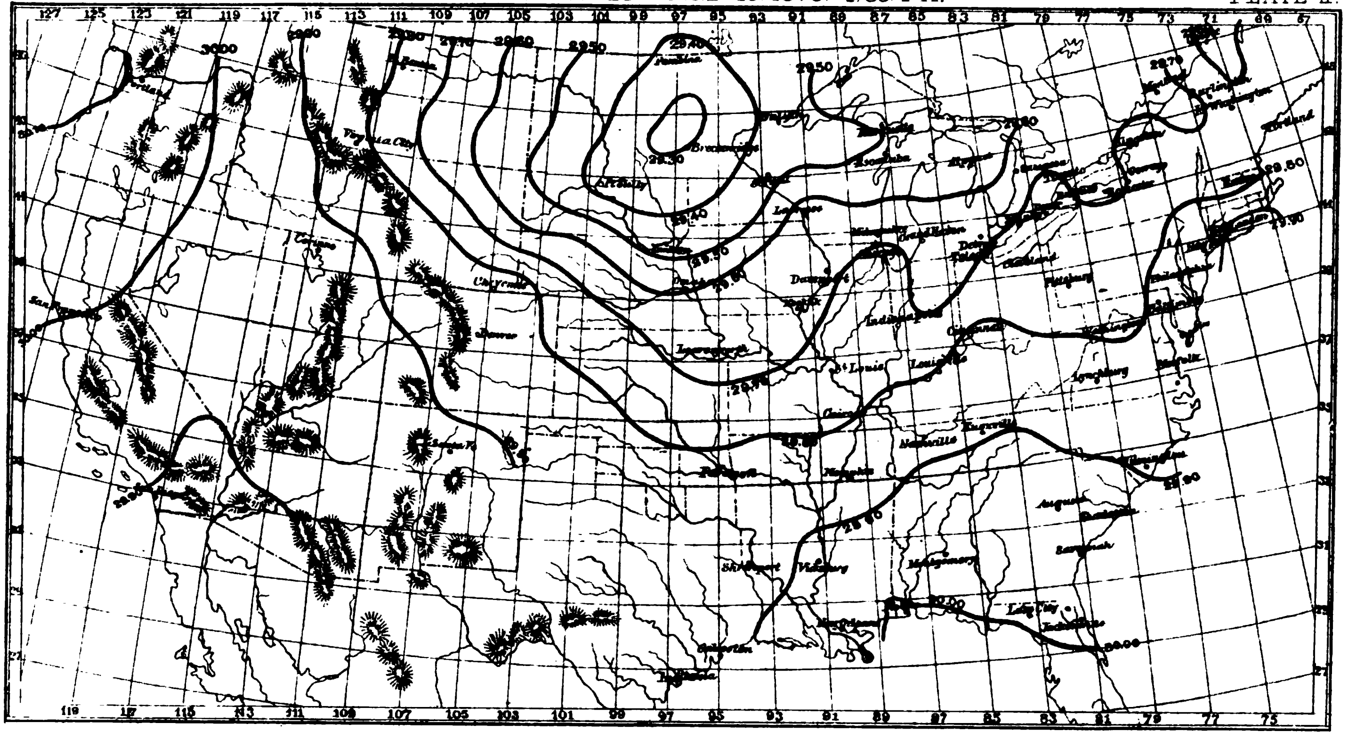


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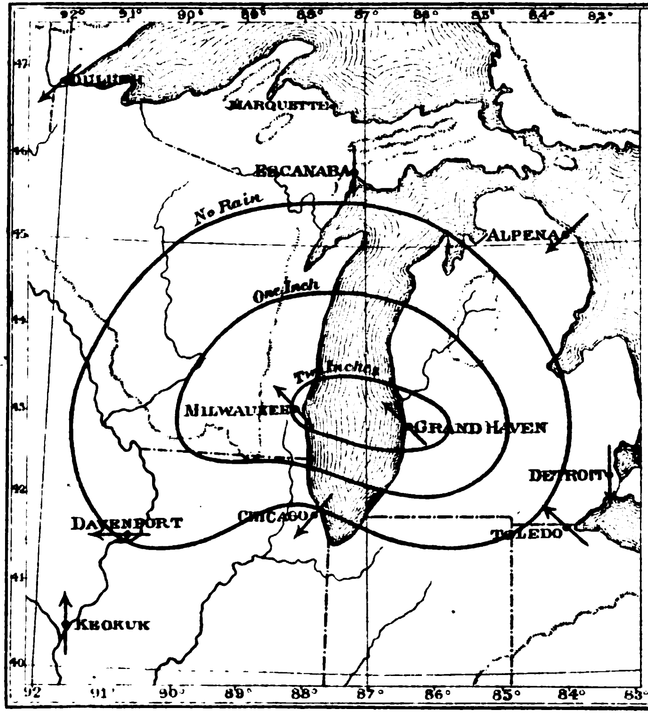
PLATE III

RAIN AREA SEPT. 23. 1872.



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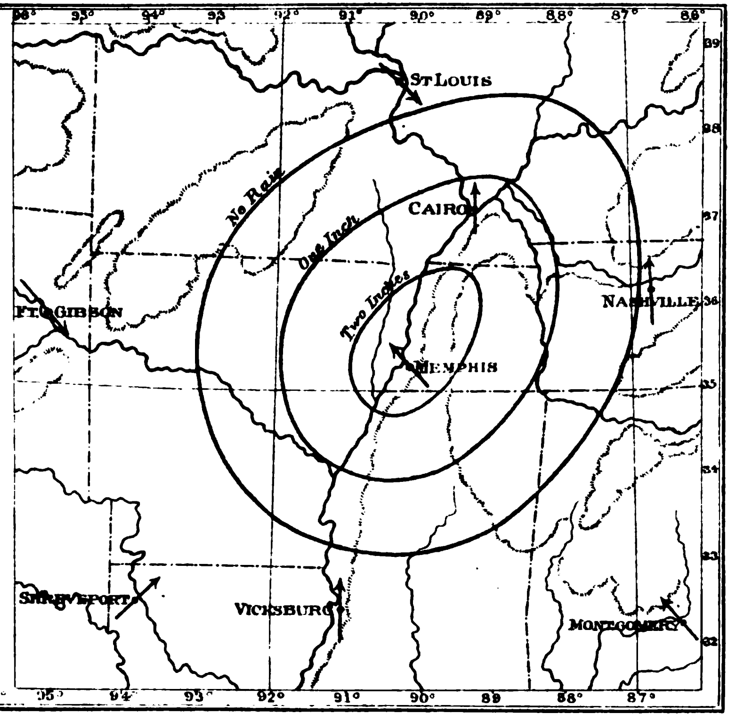

Punderson & Crisand New Haven Conn.

GEOLOGICAL REPORTS OR SURVEYS—
  Alabama, 230.
  Fortieth Parallel (King's), Microscopic Petrography, by F. Zirkel, 309.
  Kentucky, 74.
  Montana Territory, 228.
  New Jersey, 231.
  Pennsylvania, 75.
  Territories (Hayden's), 68, 229, 387, 468.
  Victoria, 157.
  West of 100th Meridian (Wheeler's), 85. 468.
  Wisconsin, 230.
Geological Society of London, 325.
GEOLOGY—
  Arctic regions, saurian from, 316.
  Balanus Estrellanus, relations of, 156.
  Basalt, 312.
  Belemnocrinus, revision of the genus, *Wachsmuth* and *Springer*, 253.
  Belgium, plutonic rocks of, 234.
  Botany, fossil, works on, 472.
  Carboniferous, relation of to Permian, 315.
  Carboniferous flora, 222.
  Connecticut valley Helderberg, 313.
  Cretaceous of Queen Charlotte Is., 157.
  Dolerytes, iron in, *Hawes*, 33.
  Earth's axis as affected by geological changes, 444.
  Elephant, fossil, 157.
  Eolian limestone of Vermont, fossils in, A. Wing, 382, 405.
  Feldspathic rocks, solubility of, 315.
  Glacial era, note on, 79.
  Glaciation of Shetland Islands, 155.
  Glaciers in the Urals, 232.
  "Greenstones" of Cornwall, 159.
  Huronian rocks of Lake Superior region, 245.
  Long Island, heights on, 235, 403.
    water-courses on, 142, 215.
  Japan, porcelain rocks of, 389.
  Kudaruyamite, 389.
  Microdiscus speciosus, *Ford*, 141.
  Miocene in Southern New Guinea, 157.
  Paleozoic fossils, catalogue of, 389.
  Pennsylvania, Paleozoic of, 384.
  Phenomena of North America, 76.
  Phosphates in rocks, 234.
  Porcelain rocks of Japan, 389.
  Port Jervis, lower Helderberg of, 385.
  Propylyte, 311.
  Rhine and Danube, the loess of, 383.
  Rhyolyte, 312.
  Rocky Mountains, age of, in Colorado, *Peale*, 172, 388; *Stevenson*, 297.
  Salt regions of Goderich, Canada, 231.
  Sandbars of Wisconsin river, 154.
  Stromatopora, 157.
  Syenitic mountains of Ditro, 159.
GEOLOGY—
  Time, estimation of, *Reade*, 314.
  Trilobites, 233.
    monograph of, 80.
    embryonic forms of, *Ford*, 265.
  Vermont, Wing's discoveries in, *Dana*, 382, 405.
  Vertebrates from Montana, 316.
  Virginia, vespertine strata of, 37, 115.
  Westfield during Champlain period, *Diller*, 262.
  Wisconsin, crystalline rocks of, 307.
Georgia, agricultural report, 245.
Gibbs, J. W., equilibrium of heterogeneous substances, 380.
Gilbert, J. H., points in connection with vegetation, 20, 99, 181.
Glass, is it impervious to gases? 464.
Glycollic acid, preparation of, 302.
Glyoxalyl-urea, decomposition of, 463.
Graduated circles, rock-crystal for, 216.
Grand'eury, Carboniferous flora, 222.
Gray, A., botanical notices, 81, 236, 320, 391, 469.
    Elliott's Botany, 81, 392.
    homogone and heterogone flowers, 82.
    Darwin on cross- and self-fertilization, 125.
    dextrorse and sinistrorse, 236, 391.
    Helianthus tuberosus, 347.
    female flower of Gnetum Gnemon, 469.
Grimaux, synthesis of allantoin, 218.
Groth, new Mineralogical Journal, 162.
Guillemin, A., Physical Forces, 245.

H

Hampe, so-called crystallized boron, 55.
Hardy, strophantine and ineine, 464.
Hartley, liquid carbon dioxide, 56.
Hawes, G. W., iron in dolerytes 33.
Hayden, F. V., publications of expedition under, 68, 229, 387, 468.
Heat as a germicide, *Tyndall*, 480.
    See *Temperature*.
Heer, O., Arctic fossil flora, 320.
Height of "West Hills," Long Isl., 403.
Henry, J., fog-signals, 151.
Henshaw, H. W., excrementitious deposits in the Rocky Mountain region, 482.
Hermann, Neptunium, 373.
Herzfeld, synthesis of coumarin, 463.
Heumann, carbon in luminous flames, 217.
Heycock, spectra of indium, 57.
Hinmann, K., luminous flames, 220.
Hitchcock, C. H., Connecticut valley Helderberg, 313.
Horne, J., glaciation of Shetland Is., 155.
Huggins, W., photographic spectra of stars, 324.

Hunt, *T. S.*, salt region of Goderich, Canada, 231.
Hydric sulphide, *Cooke*, 427.
Hydrogen in electrolysis, 217.
  purification of, 146.
Hydroquinone, preparations of, 57.
Hypovanadic oxide, 147.

I

Ice, plasticity of, 59.
Ice work in Newfoundland, 155.
Illinois Mus. Nat. Hist., Bulletin, 245.
Indium, spectra of, 57.
Induction coil, 221.
Iodine trichloride, 461.
Irving, *R.*, crystalline rocks of Wis., 307.

J

Jackson, *C. L.*, waste-product in the aniline manufacture, 449.
Jacquemin, rhodein, a new test for aniline, 219.
James, *J. B.*, compensation in chronometers, 113.
Johnson, *S. W.*, apparatus for quantitative fat-extraction; composition of sweet potato; of maize fodder, 196.
  estimation of nitrogen in nitrates, 260.
Johnson, potassium triiodide, 463.

K

Kajander, velocity of chemical reactions, 299.
Kimball, *A. S.*, laws of friction, 353.
Knobel, E. B., Catalogue of Astronomical papers and researches, 87.
Koninck, Paleozoic fossils of South Australia, 158.

L

Ladenburg, equivalence of nitrogen, 301.
Lapparent, Revue de Géologie, 315.
Lea, *M. C.*, sensitiveness to light of salts of silver, 369.
Le Conte, *J.*, note on binocular phenomena observed by Prof. Nipher, 252.
LeConte, J. L., Rynchophora, 242.
Leidy, observations on Rhizopods, 239.
Lesquereux, notices of works on vegetable paleontology, 472.
Lewis, *E.*, water courses on Long Island, 142, 215.
  heights on Long Island, 235.
Liebermann, emodin from bark of buckthorn, 148.
Light, absorption of, 304.
Lippich, absorption of light, 304.
Lippmann's electrometer, 304.
Liversidge, A., minerals of New South Wales, 162.
Lommel, fluorescence, 380, 466.
Long Island, heights of, 235, 403.
  water courses on, 142, 215.
Loomis, *E.*, contrib. to meteorology, 1.
Louguinine, constitution of the phosphates, 56.
Ludlow, W., report of a reconnaissance from Carroll, Montana Territory, 228.

M

Martin, C., origin of tender shrubs and trees in the South of France, 471.
Matthey, *M. G.*, standard meter, 149.
Matzger, *W. O.*, fossil elephant in Washington Territory, 157.
Mc Cook, habits of Formica rufa, 241.
Medicus, glyoxalyl-urea, 463.
Meek, F. B., obituary, *White*, 169.
Melezitose, 374.
Mendeleeff, Mariotte's law, 58.
Mendelsohn, beech-wood tar-creosote, 302.
Metals, diathermaneity of, 303.
Meteor of Dec. 21st, 1876, 166.
Meteoric stone and irons, *Smith*, 211.
  of Rochester, Indiana, *Shepard*, 207.
  recent falls of, *Smith*, 243.
Meteorology, contributions to, *Loomis*, 1,
  of Golden, Colorado, 326.
Meter, standard, 149.
Metric System, 244.
Meyer, *E. v.*, platinic sulphide, 301.
Meyer, *V.*, increase of weight by combustion, 304.
  equivalence of nitrogen, 373.
Microscopical Society, New York, 326.
Milne, *S.*, ice work, Newfoundland, 155.
Mineral analysis, note on, *Clarke*, 290.
Mineralogical Magazine, 162.
Mineralogy, Groth's Journal of, 162.
MINERALS—
  Barite from Missouri, *Broadhead*, 419.
  Columbite, 361, 362.
  Enysite, 162.
  Euxenite, 365, 369.
  Fergusonite, 367, 369.
  Göthite from Missouri, *Broadhead*, 420.
  Guanajuatite, 319.
  Hatchettolite, 365, 369.
  Henwoodite, 162.
  Hermannolite, 390.
  Hydrocastorite, 318.
  Iron in dolerytes, *Hawes*, 33.
  Lawrencite, 318.
  Ludlamite, 318.
  Microlite, 368.
  Opal, 326.
  Peganite, identity of, *Chester*, 295.
  Pelagite, 318.
  Rogersite, 367, 369.
  Samarskite, 234, 362, 369, 390.
  Scheelite containing gold, 451.
  Sepiolite, fibrous, *Chester*, 296.

MINERALS—
Silaonite, 319.
Strengite, 318.
Triphylite, *Penfield*, 425.
Yttrotantalite, 369.
Missouri, chemical contributions, 468.
Molecular volumes, *Clarke*, 292.
weights and heat-absorbing power of chemical substances, 217.
Moon, Hansen's tables of, 87.

N

Naphthalenes, 148.
Neesen, the radiometer, 466.
Neptunium, a new metallic element, 373.
Newcomb, S., investigation of corrections to Hansen's tables of the Moon, 87.
New Jersey, Agricultural report, 482.
Newton, H. A., meteor of Dec. 21st, 1876, 166.
Nilson, plato- and diplato-nitrites, 147.
Nipher, F. E., binocular vision, 35.
Nitric acid, action of on coal gas, 301.
Nitrites, plato- and diplato-, 147.
Nitrogen, action of ozone on, 372.
compounds, 58.
equivalence of, 301, 373.
in nitrates, estimation of, *Johnson*, 260.
Nova Scotia, Institute of Nat. Sci., proceedings of, 321.

O

OBITUARY—
Bennett, J. J., 237.
Braun, Alexander, 471.
Brongniart, A. T., 237.
Carson, Joseph, 238.
Davis, Rear Admiral C. H., 246.
Ehrenberg, C. G., 238.
Forbes, David, 88.
Fückel, Leopold, 238.
Hofmeister, Wilhelm, 238.
Meek, F. B., 88, 169.
Newman, Edward, 238.
Notaris, Joseph de, 322.
Poggendorf, J. C., 246.
Smee, Alfred, 246.
Smith, Lady, 321.
Waltershausen, W. S. von, 326.
Wilkes, Rear Admiral Charles, 246.
Observatory, U. S. Naval, instruments and publications of, 242.
Organic liquids, phosphorescence of, 374.

P

Palaeontographica of Prussia, 389.
Palladium, in alcohol flame, 148.
Paper, diathermaneity of, 303.
Peale, A. C., age of the Rocky Mountains in Colorado, 172, 388.
Peirce, C. S., sensation of color, 247.
Penfield, S. L., chemical composition of triphylite, 425.
Pennsylvania, paleozoic rocks of central, 384.
Peters, C. H. F., orbit of Urda (167), 112.
a new planet, 242.
Petterson, atomic weight of selenium, 462.
Phillips, J. A., "Greenstones" of Western Cornwall, 159.
Phosphates, constitution of, 56.
Phosphorescence of organic liquids, 374.
Phthaleins, 149.
Physics, researches in, 67.
Pickering, E. C., physical notices, 58, 149, 219, 303, 378, 464.
Pierre, alcohol from the leaves of the sugar beet, 218.
Planets, new, 242, 397.
Platinic sulphide, oxidized, 301.
Potassium triiodide, *Johnson*, 463.
Poussin, plutonic rocks of Belgium, 234.
Prescott, G. B., Electricity and the Electric Telegraph, 467.
Pressures, high, measurement of, 303.

Q

Quincke, is glass impervious to gases? 464.

R

Radiometer, 466.
Radsiszewski, phosphorescence of organic liquids, 374.
Rainbow, polarization of, 465.
Rath, G., syenitic mountains of Ditro, 159.
Reade, T. M., geological time, 314.
Retina, a property of, *Rood*, 32.
Rhodein, a new test for aniline, 219.
Ricketts, P. de P., notes on assaying, 87.
Ridout, R. H., sensitive flames, 219.
Rood, O. N., a property of the retina, 32.

S

Sabine, velocity of electricity, 60.
Scharff, F., structure of calcite, 319.
Schiff, constitution of cyanamide, 462.
Schobig, purification of hydrogen gas, 146.
Schott, C. A., magnetic declination in United States, 85.
Schuler, hydroquinone, 57.
Schultz, decomposition of turpentine, 302.
Selenium, atomic weight of, 462.
Shaler, N. S., memoirs of the geological survey of Kentucky, 226.
Shepard, C. U., Meteoric stone of Rochester, Indiana, 207.
Shoal in the Atlantic, 326.
Silliman, B., alcoholic strength of Australian wines, 87.
scheelite containing gold, 451.

Silver salts, sensitiveness of, *Lea*, 369.
Siphon-recorder, 152.
Skinner, *A. N.*, Borelly's comet, 323.
Smith, E. A., geology of Alabama, 230.
Smith, *E. F.*, derivatives of benzol, 375.
Smith, *J. L.*, examination of Waconda meteorite and meteoric irons, 211.
  new localities of columbic acid minerals, and new columbates, 234.
  recent fall of meteoric stones, 243.
  examination of American minerals, 359.
Smithsonian Report for 1875, 168.
Smyth, *G. A.*, copulated compounds of sulphur, 305.
Smyth, *R. B.*, Geological Report, 157.
Sonnenschein, Gelsemium sempervirens, 58.
Spectra of Venus, and α Lyrae, photographs of, *Draper*, 95.
Spectrum, ultra red, 379.
Spottiswoode, *W.*, large induction coil, 221.
Sprague, I., Wild flowers of America, 84.
Springer, *F.*, Belemnocrinus, 253.
Star, new, in Cygnus, 395.
Stars, spectra of, 324.
Stein, rock-crystal, balance-beams, thermometers, and graduated circles, 216.
Stevenson, *J. J.*, on Peale's notes on age of the Rocky Mountains, 297.
Storer, *F. H.*, phosphates and potash in rocks, 234.
Structure of precious opal, 326.
Struve, equivalence of nitrogen, 301.
Sulphur, copulated compounds of, 305.

T

Tait, P. G., Lectures on recent advances in physical science, 222.
Tar-creosote, constituents of, 302.
Telephone, 402.
Temperatures, underground, 452.
Thacher, J. K., on fins, 323.
Thermometers, rock-crystal for, 216.
Tiemann, beech-wood tar-creosote, 302.
  synthesis of coumarin, 463.
Todd, D. P., satellites of Jupiter, 325.
Torell, *O.*, glacial phenomena of North America, 76.
Trowbridge, *J.*, vortex rings, 327.
Trumbull, *J. H.*, Helianthus tuberosus, 347.
Turpentine, decomposition of oil of, 302.
Tylor, films of water, 151.
Tyndall, *J.*, development of organisms in organic infusions, 477, 480.

U

Urda (167), orbit of, *Peters*, 112.

V

Vacher, A., primer of chemistry, 482.
Villiers, melezitose, 374.
Vision, binocular, 35, 252.
Vogdes, A. W., American Trilobites, 80.
Vortex rings in liquids, *Trowbridge*, 327.

W

Wachsmuth, *C.*, Belemnocrinus, 253.
Walcott, *C. D.*, Trilobites, 233.
Waldstein, emodin from the bark of buckthorn, 148.
Warren, *G. K.*, transportation route along Wisconsin and Fox rivers, 152.
Wartha, *M.*, influence of pressure on combustion, 220.
Water, films of, 151.
Weselsky, hydroquinone, 57.
Weyrauch, J. J., structures of iron and steel, 403.
Wheeler, G. M., geol. report of, 85, 468.
White, *C. A.*, In memoriam, Meek, 169.
Whiteaves, *J. F.*, Mesozoic fossils, 157.
Whitney, J. D., origin of forests and prairie regions, 81.
Wilkinson, *C. S.*, Miocene in southern New Guinea, 157.
Winds of the Globe, *Coffin*, 273.
Wines, alcoholic strength of, 87.
Wing, *A.*, fossils in Eolian limestone, 382, 405.
Wöhler, palladium in alcohol flame, 148.
Wood spirit, detection of alcohol in, 218.
Wright, *A. W.*, production of metallic films by electrical discharge, 49.
Wurtz, H., porcelain and porcelain rocks of Japan, 320, 389.

Z

Zirkel, F., microscopical Petrography, 309.
Zodiacal light, 399.
Zöllner, the radiometer, 466.
ZOOLOGY—
  Bison, living and extinct, 75.
  Copper in blood of animals, 464.
  Corals, rate of growth of, 166.
  Challenger expedition, 165.
    Echinoderms of, 164.
  Echidna, new, from New Guinea, 242.
  Fins, median and paired, 323.
  Formica rufa, habits of, 241.
  Halibut, flesh of, 123.
  Locust in Manitoba, 401.
  Organisms in infusions, 477, 480.
  Ornithological club, bulletin of, 166.
  Rhizopods, observations on, 239.
    See also under GEOLOGY.

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CONTENTS OF VOLUME XIV.

NUMBER LXXIX.

Page

ART. I.—Contributions to Meteorology, being results derived from on examination of the United States Weather Maps, and from other sources (Pl. 1, 2, 3); by **ELIAS LOOMIS**,.. 1

II.—Germination of the genus *Megarrhiza*, Torr.; by **A. GRAY**, 21

III.—The absorption of Bases by the Soil; by **H. P. ARMSBY**, 25

IV.—Double-Star Discoveries with the 18½-inch Chicago Refractor; by **S. W. BURNHAM**,.......................... 31

V.—Supplement to the Account of the Discoveries in Vermont of the Rev. Augustus Wing; by **JAMES D. DANA**,.. 36

VI.—On the relations of the Geology of Vermont to that of Berkshire; by **JAMES D. DANA**,.......................... 37

VII.—On certain new and powerful means of rendering visible the Latent Photographic Image; by **M. CAREY LEA**,... 49

VIII.—On the possibility of Transit Observation without Personal Error; by **S. P. LANGLEY**,.................. ... 55

IX.—Observations of Comets; by **C. H. F. PETERS**,........ 60

X.—On Complex Inorganic Acids; by **WOLCOTT GIBBS**,.... 61

XI.—Characters of Coryphodontidæ (Pl. 4); by **O. C. MARSH**, 81

XII.—Characters of Odontornithes (Pl. 5); by **O. C. MARSH**. 85

XIII.—New and Gigantic Dinosaur; by **O. C. MARSH**,..... 87

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Effect of Pressure on Chemical Action, **BERTHELOT**: New method of determining the Specific Gravity of a readily decomposable body, **CHRISTOMANOS**, 64.—Determination of High Melting Points, **CARNELLEY**, 65.—New Vapor Density Method, **GOLDSCHMIEDT** and **CIAMICIAN**: Condensation of Isobutylene, **BOUTLEROW**: New method of producing Salicylic acid, **HERMANN**, 66.—Formation of Coumarin, and of Cinnamic and other analogous acids, **PERKIN**: New Urea reaction, **SCHIFF**: Notes from the Chemical Laboratory of the Johns Hopkins University, 67.

Geology and Mineralogy.—Volcanic Eruptions on Hawaii, Rev. **TITUS COAN**, 68.—Geological Survey of Pennsylvania: U. S. Geological and Geographical Survey of the Territories, 69.—Geological Survey of Canada: Shifting of the earth's axis, Haughton, 70.—Samarskite of North Carolina: Analysis of Samarskite, 71.

Botany and Zoology.—Development and Systematic Arrangement of the Pithophoraceæ, V. B. **WITTROCK**: Ueber Sprossung der Moosfrüchte und den Generationswechsel der Thallophyten, **PRINGSHEIM**, 71.—Algæ Exsiccatæ Americæ Borealis, W. G. **FARLOW**, C. L. **ANDERSEN** and D. C. **EATON**: Orchis rotundifolia: Beiträge zur Entwickelungsgeschichte der Flechten, E. **STAHL**, 72.—North American Starfishes, A. **AGASSIZ**: Ninth Annual Report on the Insects of the State of Missouri, C. V. **RILEY**, 73.—Bulletin of U. S. Entomological Commission, 74.

Astronomy.—Astronomical and Meteorological Observations at the U. S. N. Observatory, 74.—Astronomical Observatory of Harvard College: Meteoric Fireballs: On the part of the motion of the lunar perigee which is a function of the mean motions of the Sun and Moon, G. W. **HILL**, 75.—Chicago Observatory: The Observatory, a Monthly Review of Astronomy: An Elementary Treatise on Elliptical Functions, 76.

Miscellaneous Scientific Intelligence.—American Association: New American Scientific Museums, 76.—Earthquake oceanic wave: Treatise on Lightning Protection: Natural Philosophy for Beginners, 77.—Vermont Board of Agriculture, Manufactures and Mining: Wisconsin Academy of Sciences, Arts and Letters: Academy of Natural Sciences of Philadelphia, 78.—*Obituary.* Elkanah Billings, 78. —E. Jewett: P. P. Carpenter: R. D. Owen, 80.

NUMBER LXXX.

Page

Art. XIV.—Discovery of Oxygen in the Sun by Photography, and a new Theory of the Solar Spectrum (with Plate VI); by H. Draper, 89

XV.—Action of certain Organic Substances in increasing the Sensitiveness of Silver Haloids; by M. C. Lea, 96

XVI.—Critical Periods in the History of the Earth and their Relation to Evolution; by Joseph LeConte, 99

XVII.—Notes on the internal and external structure of Paleozoic Crinoids; by Charles Wachsmuth, 115

XVIII.—Chemical constitution of Hatchettolite and Samarskite; by Oscar D. Allen, 128

XIX.—Relations of the Geology of Vermont to that of Berkshire; by James D. Dana, 132

XX.—A proposed new method in Solar Spectrum Analysis; by S. P. Langley, 140

XXI.—Note on the Exactitude of the French Normal Fork; by Rudolph Koenig, 147

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—On the Heat of Combustion of Oxygen and Hydrogen in closed vessels, Than, 148.—Vapor volumes and Avogadro's Law: Plato-diiodo-dinitrosyl and Triplato-octonitrosylic acid, Nilson, 149.—Action of Bromine upon Pyrotartaric Acid, Bourgoin, 150.—Polybasic acids obtained by the action of Carbon dioxide on Phenol, Ost: Relation of Cystin to Sulphates in the Urine. Niemann, 151.—Gauss's Theory of Capillarity: Influence of Light upon the Electrical resistance of Metals, Börnstein: Chemical and Physical Researches, Thomas Graham, 152.

Geology and Mineralogy.—Bulletin, Vol. iii, No. 3, of Hayden's Expedition, 154.—The Coal Mines of the Western Coast of the United States, W. A. Goodyear: Origin of Kames or Eskers in New Hampshire, Warren Upham: The American Palæozoic Fossils, S. A. Miller, 156.—Heights of Mountains in Western Connecticut: Some of the conditions influencing the projection of discrete solid materials from Volcanoes: The Geological Survey of Portugal, 157.—Earthquake of Jalisco, Mexico, and eruption of the Volcano Ceboruco: West Rock at New Haven, Connecticut, not the termination of the Green Mountain range, 158.

Botany and Zoology.—Some points of Botanical Nomenclature, 158.—Athamantha Chinensis L.: Repertorium Annum Literaturæ Botanicæ periodicæ curarunt G. C. W. Brohnensieg, 160.—Sir Joseph Dalton Hooker and party on a Botanical excursion to the Rocky Mountains and California: The Influence of Physical Conditions in the Genesis of Species, Joel A. Allen: Sir Wyville Thomson, and the working up of the "Challenger" collections, 161.—American Addresses, with a Lecture on the study of Biology, Thomas H. Huxley, 162.

Astronomy.—Notice of the Meteor of June 12, 1877, Daniel Kirkwood: Micrometric measurement of Double Stars: Chicago Observatory: Handbook of Descriptive Astronomy, George F. Chambers, 163.

Miscellaneous Scientific Intelligence.—Abstract of a pamphlet entitled Reflections sur les Chronometres, J. A. Rouyaux, 164.—Earthquake wave of May 9th and 10th, 166.—Tides of the Arctic Seas: Massachusetts Institute of Technology, Boston: Transfer of the Shepard Collections to Amherst College: Imperial Academy of Sciences of St. Petersburg: National Academy of Sciences, 167.—Bulletin of the Bussey Institution: Dynamics, or Theoretical Mechanics, J. T. Bottomley, 168.—*Obituary.*—Sanborn Tenney: Dr. Stephen Reed: C. F. Winslow, M.D., 168.

NUMBER LXXXI.

Page

Art. XXII.—On a new Process for the Electrical Deposition of Metals, and for constructing Metal-covered Glass Specula; by A. W. Wright, 169

XXIII.—A new and ready method for the Estimation of Nickel in Pyrrhotites and Mattes; by M. S. Cheney and E. S. Richards, 178

XXIV.—Notes on the internal and external structure of Paleozoic Crinoids; by C. Wachsmuth, 181

XXV.—Phenomena of Binocular Vision; by J. LeConte, 191

XXVI.—Ethylidenargentamine-ethylidenammonium Nitrate; by W. G. Mixter, 195

XXVII.—On the crystalline form of the hydrous and anhydrous varieties of Ethylidenargentamine-ethylidenammonium Nitrate; by E. S. Dana, 198

XXVIII.—The relations of the Geology of Vermont to that of Berkshire; by J. D. Dana, 202

XXIX.—On the preparation of Cylinders of Zirconia for the Oxy-hydrogen Light; by J. C. Draper, 208

XXX.—Occurrence of Garnet with the Trap of New Haven; by E. S. Dana, 215

XXXI.—Description of the Rochester, Warrenton, and Cynthiana Meteoric Stones, with some remarks on the previous falls of Meteorites in the same regions; by J. L. Smith, 219

XXXII.—Notice of a new genus of Annelids from the Lower Silurian; by G. B. Grinnell, 229

XXXIII.—New Vertebrate Fossils; by O. C. Marsh, 249

SCIENTIFIC INTELLIGENCE.

Physics.—The Radiometer, Cooke, 231.

Geology and Mineralogy.—Gravel deposits referred to the Drift, in Boone County, Kentucky, G. Sutton: Gravel Ridges in the Merrimack valley, G. F. Wright, 239.—On the supposed Fossil Tracks called Protichnites and Climatichnites, E. J. Chapman: Glaciers of the Swiss Alps in the Glacial era: Geology of New Hampshire: Lithology of the Adirondacks, 240.—New method of determining the species of Feldspars, J. Szabó, 241.—Notices of some newly described minerals, 242.

Botany and Zoology.—Rapid growth of Vallisneria spiralis: Evolutionary law as illustrated by abnormal growth in an Apple tree, T. Meehan, 243.—Remarks on the Yellow Ant, Leidy: Sexual Dimorphism in Butterflies, 244.

Miscellaneous Scientific Intelligence.—Narrative of the North Polar Expedition, 245.—The American Meteorologist: The American Journal of Pure and Applied Mathematics: Publications of the Cincinnati Observatory: Two new Meteoric Irons: Table of Logarithms: Tenth Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology, 246.—Kinetic Theories of Gravitation, W. B. Taylor, 247.

Obituary.—Timothy Abbott Conrad, 247.—Robert Were Fox, 248.

NUMBER LXXXII.

Page

Art. XXXIV.—On the relations of the Geology of Vermont to that of Berkshire; by J. D. Dana, ... 257

XXXV.—Address before the Department of Anthropology of the British Association at Plymouth; by F. Galton,... 265

XXXVI.—Analyses of Cast Nickel, and Experiments on the combining of Carbon and Silicon with Nickel; by W. E. Gard, ... 274

XXXVII.—On the practical use of Autography, especially for Natural History publications; by G. O. Sars,...... 277

XXXVIII.—On the Iodates of Cobalt and Nickel; some Specific Gravity determinations; and an Analysis of Sylvanite from Colorado; by F. W. Clarke,................. 280

XXXIX.—Notes on the Analysis of Bituminous Coal; by T. O'C. Sloane, ... 286

XL.—A Preliminary Catalogue of the Reptiles, Fishes and Leptocardians of the Bermudas, with descriptions of four species of Fishes believed to be new; by G. B. Goode,.. 289

XLI.—History of Cavern Exploration in Devonshire, England; by W. Pengelly,........................... 299

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Modification of Dumas's Vapor-density method, Habermann: Action of Phosphoric chloride on Tungstic oxide, Teclu. 309.—Production of Tartronic from Pyruvic acid, Grimaux: Hexyl Chloral, Pinner: Conversion of Aurin into Rosaniline, Dale and Schorlemmer, 310.—Hematin, Cazeneuve: Nature of what is commonly called a "Vacuum," G. J. Stoney, 311.—Note on the Telephone, P. Higgs, 312.

Geology and Mineralogy.—Archæan of Canada, H. G. Vennor, 313.—Geology of New Hampshire, C. H. Hitchcock, 316.—Preliminary Report on the Paleontology of the Black Hills, R. P. Whitfield: Age of the Tejon group, California, J. G. Cooper, 321.—Fossil Tertiary Insects of Quesnel, S. H. Scudder: First discovered traces of Fossil Insects in American Tertiaries, S. H. Scudder, 322.—Geological Survey of Victoria: Tantalite, J. L. Smith: Geognostische und geographische Beobachtungen im Staate Minnesota, J. H. Kloos, 323.

Botany and Zoology.—Morphology of the Dentary System in the Human Race, E. Lambert, 323.—Arbeiten aus dem zoologische-zootomischen Institut im Würtzburg, 324.—Brain of Chimæra monstrosa, B. G. Wilder, 325.

Astronomy.—New Planets, J. C. Watson: Time of Rotation of Saturn, A. Hall, 325.—The newly discovered satellites of Mars, 326.—American Ephemeris and Nautical Almanac for the year 1880: Does the Motion of the inner satellite of Mars disprove the Nebular Hypothesis? D. Kirkwood. 327.

Miscellaneous Scientific Intelligence.—American Association for the Advancement of Science, 328.—Distant Points visible from Mt. Washington, W. H. Pickering, 331.—Caution to Archæologists, 333.—Handbook of Hygiene and Sanitary Science, Wilson: British Association: New Constructions in Graphical Statics, H. T. Eddy, 335.—*Obituary.*—Henry Newton, 335; Moses Strong, Adolf Erman, 336.

NUMBER LXXXIII.

Page
ART. XLII.—Introduction and Succession of Vertebrate Life in America; by O. C. MARSH, ... 337
XLIII.—Note on the Helderberg Formation of Bernardston, Massachusetts, and Vernon, Vermont; by J. D. DANA, . 379
XLIV.—History of Cavern Exploration in Devonshire, England; by W. PENGELLY, ... 387
XLV.—Is the Existence of Growth-rings in the Early Exogenous Plants proof of Alternating Seasons? by CHARLES B. WARRING, ... 394
XLVI.—On Sipylite, a new Niobate, from Amherst County, Virginia; by J. W. MALLET, ... 397
XLVII.—Mean Motion of the Moon; by SIMON NEWCOMB, .. 401

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Action of Saline solutions on Lead, MUIR: New Method for the Synthesis of Hydrocarbons, FRIEDEL and CRAFTS, 411.—The Terpenes of Swedish Wood Tar, ATTERBERG: Amylene from Amyl Iodide, ELTEKOFF, 412.—Constitution of unsaturated Dibasic Acids, FITTIG, 413.—Phenol of Phenanthrene, Phenanthrol, REHS: Formation of Rosolic Acid from Cresol and Phenol, ZULKOWSKY: A new Coloring matter, HOFMANN, 414.—Examination of a Nickel magnet, H. WILD: Spectroscope with a Fluorescent Eye-piece, M. J. L. SORET, 415.—Sun's Heat, M. A. CROVA: Changes in the Spectra of Gases caused by increasing tension: The Influence of Light in Chemical Changes, M. P. CHASTAING, 416.—Magnetic rotatory Polarization, M. H. BECQUEREL, 417.—Rose-colored Sulphide of Manganese: Analysis of Alkaline Sulphides and Sulphocarbonates, M.M. DELACHANAL et MERMET: Separation of Potassium from Sodium, SCHLOESING: Volumetric method of determining the amount of Manganese in iron ores, M. G. PARREÑO, 418.—Light, etc., A. M. MAYER and C. BARNARD: Manual of Inorganic Chemistry, T. E. THORPE: System of Volumetric Analysis, by Dr. Emil Fleischer, M. M. P. MUIR, 419.

Geology and Mineralogy.—Geological and Geographical Survey of the Territories, F. V. HAYDEN, 420.—Fifth Annual Report of the Geological and Natural History Survey of Minnesota, N. H. WINCHELL. 422.—Geological Record for 1875, W. WHITAKER: Notice of Hetærolite: a new Mineral Species, G. E. MOORE: On some Tellurium and Vanadium Minerals, F. A. GENTH, 423.—Mineralogische Mittheilungen, G. VOM RATH: Elemente der Mineralogie, C' F. NAUMANN, 424.

Botany and Zoology.—Occurrence of another gigantic Cephalopod on the coast of Newfoundland, A. E. VERRILL, 425.—The Antelope and Deer of America, J. D. EATON: Life Histories of the Birds of Eastern Pennsylvania, T. G. GENTRY: Zoologische Wandtafeln, R. LEUCKART and H. NITSCHE: Bulletin of the U. S. National Museum, T. H. STREETS: Notes on some Common Diseases [of plants] caused by Fungi, W. G. FARLOW, 426.—Flora Brasiliensis: Botany of British Columbia and Northern Rocky Mountains: Sketch of the Vegetation of the Nicobar Islands, S. KURZ, 457.—Arboretum Segrezianum, A. LAVALLÉE: Systema Iridacearum, J. G. BAKER: Native "Artichokes," 428.—Necrological, 429.

Astronomy.—Discovery of a New Planet, C. H. F. PETERS, 429.—Comets in 1877: Observations and Orbit of Tempel's Comet, 430.

Miscellaneous Scientific Intelligence.—Davenport Academy of Natural Sciences, 430.—U. S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. POWELL: Burial Customs of North American Indians, H. C. YARROW: On the Science of Weighing and Measuring, H. W. CHISHOLM: How to draw a Straight Line, A. B. KEMPE: The Elements of Descriptive Geometry, S. E. WARREN, 431.—Smithsonian Report for 1876, 432.—*Obituary.*—Urban J. J Leverrier, John G. Anthony, Benjamin Hallowell, 432.

NUMBER LXXXIV.

Page

ART. XLVIII.—On the Proper Motion of the Trifid Nebula; by **EDWARD S. HOLDEN**, ... 433

XLIX.—The Northern Part of the Connecticut Valley in the Champlain and Terrace Periods; by **WARREN UPHAM**, ... 459

L.—Descriptions of two new species of Fishes; by **G. BROWN GOODE** and **TARLETON H. BEAN**, ... 470

LI.—Volumetric Determinations by Chromic Acid; by **C. W. HINMAN**, ... 478

LII.—New Order of Extinct Reptilia (Stegosauria) from the Jurassic of the Rocky Mountains; by **O. C. MARSH**, ... 513

LIII.—Notice of new Dinosaurian Reptiles from the Jurassic formation; by **O. C. MARSH**, ... 514

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—On the Gases enclosed in Lignite, **THOMAS**, 481.—On the Reaction between Insoluble Carbonates and Soluble Oxalates, **WATSON SMITH**: On the new Metal Davyum, 482.—Upon Metalacetyl-acetic ethers, **CONRAD**: On Phyllic acid, extracted from leaves, **BOUGAREL**, 483.—On the Constitution of Euxanthon, **SALZMANN** and **WICHELHAUS**: Density of Vapors, 484.—New Results in Physics, 486.

Geology and Mineralogy.—China, **F. F. VON RICHTHOFEN**, 487.—International Geological Congress, 491.—Palæontology of New York, **JAMES HALL**, 493.—Twenty-eighth Annual Report of the New York State Museum of Natural History: Notes on some new sections of Trilobites from the Trenton Limestone, **C. D. WALCOTT**, 494.—Large Bowlders in New Hampshire: Application of Organic Acids to the Examination of Minerals, **H. C. BOLTON**, 495.—Note on Uranium minerals in North Carolina, **W. C. KERR**, 496.

Botany and Zoology.—Wild Flowers of America, **ISAAC SPRAGUE** and **GEORGE L. GOODALE**: Cleistogamy in Impatiens, 497.—Catalogus Plantarum in Nova Cæsarea Repertarum: **SIR JOSEPH DALTON HOOKER**, 498.—**GEORGE HADLEY, M.D.**: **JOHN DARBY**, 499.—Herbarium for sale: Zoological Diagrams, **LEUCKART** and **NITSCHE**, 500.

Astronomy.—The Sun's Distance, 501.

Miscellaneous Scientific Intelligence.—Notes on the Rocky Mountains, Sir **JOSEPH HOOKER**, 505.—The Earths found in the North Carolina Samarskite: Artificial Tremors through the Earth's Crust, **HENRY L. ABBOTT**, 509.—Recherches expérimentales, **M. DAUBRÉE**, 510.—National Academy of Science, 511.—Canada and New England Earthquake: Thin Sections of Rocks, Minerals, etc., 512.—*Obituary*—James Orton, 512.

ERRATUM.

On page 61 line 8, for *Swift-Borelly* read *Block-Swift-Borelly*.
Page 248, line 7 from foot, for *depth* read *heat*.
Page 335, line 10 from foot, for the period insert a comma.
Page 426, line 3, for **EATON** read **CATON**.

THE
AMERICAN
JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. I.—*Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by Elias Loomis, Professor of Natural Philosophy in Yale College. Seventh paper. With plates I, II and III.

[Read before the National Academy of Sciences, Washington, April 18, 1877.]

Rain-areas—their form, dimensions, movements, distribution, etc.

In my last paper I examined all those cases in which the rain-fall was uncommonly great at any one of the Signal Service stations during a period of fifteen months (Sept. 1872, to Nov. 1873). I propose now to consider those cases in which the *total* rain-fall for all the stations was uncommonly great. The following table exhibits all the cases in which the total rain-fall at all the stations amounted to at least eight inches in a period of eight hours. Column 1st contains the number of reference; column 2d shows the day and hour of observation (the numeral one denotes the observation at 7^h 35^m A. M.; two denotes the observation at 4.35 P. M.; and three denotes 11 P. M.) column 3d shows in inches the total rain-fall at all the stations during the preceding eight hours; column 4th shows the station at which the greatest rain-fall was recorded; column 5th shows the amount of rain observed at the station mentioned in column 4th; column 6th shows the state of the barometer at the same station; column 7th shows the state of the barometer at the nearest center of minimum pressure; column 8th shows the direction of the rain center mentioned in column 4th from the center of low pressure mentioned in column 7th; column 9th shows the distance of the rain center from the center of low

Am. Jour. Sci.—Third Series, Vol. XIV, No. 79.—July, 1877.

Total rain-fall at all the stations amounting to at least eight inches in eight hours.

No.	Date.	Total rain-fall.	Station of greatest rain.	Rain at do.	Bar. at do.	Low bar.	Rain center from Low. Direction.	Rain center from Low. Distance.	Wind at prev. ob.	Wind at date.
	1872.									
1	Sept. 11.3	10·76	Marquette.	1·91	29·80	29·74	N. 5° W.	287	S.E. 1	W. 1
2	12.2	9·93	Saugeen.	1·74	·74	·68	N. 40 W.	78	S. 3	Calm.
3	Oct. 6.3	8·75	Vicksburg.	1·05	30·02				N. 8	E. 3
4	7.2	8·58	Montreal.	1·35	29·90	·81	North.	156	S.W. 2	N.E. 3
5	22.3	8·30	Jacksonville.	2·43	·99				N.E. 12	E. 13
6	23.1	9·34	Jacksonville.	2·05	·83				E. 13	W. 1
7	25.1	8·91	Norfolk.	3·41	·95	·95	*	0	E. 13	S.E. 8
8	26.1	8·80	Philadelphia.	2·09	·78	·74	S. 65 E.	137	E. 20	S.W. 12
9	Nov. 6.3	9·91	Montgomery.	2·73	·95				E. 3	S..E 22
10	7.1	13·52	New York.	2·50	·68	·33	S. 54 E.	777	S.E. 4	N.W. 10
11	Dec. 18.2	8·77	New Orleans.	2·20	30·08				S.W. 6	N.E. 8
12	20.1	14·49	New York.	1·70	29·78	·43	S. 55 E.	287	N.E. 17	N.W. 20
13	26.1	9·46	Norfolk.	2·08	·46	·46	*	0	N.E. 21	N. 20
	1873.									
14	Jan. 2.2	9·12	Keokuk.	1·63	·35	·23	S. 44 W.	134	Calm.	W. 12
15	3.1	8·63	New York.	1·80	·83	·09	S. 57 E.	761	N.E. 16	E. 6
16	5.1	12·74	Lake City.	2·00	·89				S.E. 4	S.E. 7
17	5.2	16·25	Philadelphia.	2·18	·61	·45	S. 58 E.	218	N.E. 20	N.E. 8
18	16.1	10·08	New Orleans.	2·01	·92				S. 8	N.W. 12
19	17.1	8·05	Philadelphia.	1·07	·80	·54	S. 36 W.	630	S.W. 18	N.W. 18
20	Feb. 16.1	10·57	Louisville.	1·60	·56	·49	East.	195	N.E. 8	Calm.
21	16.2	9·87	Cape May.	1·54	·66	·55	N. 87 E.	448	E. 18	S. 6
22	26.2	8·88	Knoxville.	1·23	·80	·36	S. 39 E.	507	E. 5	Calm.
23	Mar. 29.1	10·65	Lake City.	2·00	·97				N.E. 8	N.W. 12
24	29.2	10·48	Oswego.	1·48	·01	·01	*	0	S.E. 12	N.E. 12
25	April 8.1	8·70	Indianapolis.	1·08	·71	·64	N. 46 E.	343	N.E. 7	E. 4
26	8.2	8·57	St. Louis.	1·65	·64	·52	N. 82 W.	245	N. 34	W. 9
27	May 1.2	9·37	Montgomery.	3·05	·87				S.E. 4	S.E. 4
28	2.1	11·78	Wilmington.	1·01	·88				S. 12	N.E. 2
29	2.2	8·49	Wilmington.	1·02	·68				N.E. 2	S.W. 30
30	8.1	8·33	Lynchburg.	1·37	·98	·59	S. 57 E.	562	N.E. 12	N.E. 8
31	June 23.1	8·65	St. Paul.	2·30	·57	·52	S. 67 E.	93	S.E. 18	S.W. 2
32	30.2	9·23	Port Stanley.	1·81	·56	·36	S. 60 E.	591	S.W. 3	S.W. 3
33	July 17.3	10·88	Buffalo.	2·00	·64	·64	*	0	S.W. 14	S.W. 7
34	27.2	9·63	Washington.	2·12	30·11	·72	S. 63 E.	1175	S. 10	W. 8
35	Aug. 12.2	8·45	Galveston.	1·68	·04				N. W. 4	W. 2
36	13.1	9·52	Philadelphia.	2·31	·04	·92	N. 73 E.	346	E. 16	N.E. 12
37	13.2	8·27	Philadelphia.	2·17	29·97	·85	N. 41 E.	348	N.E. 12	N.E. 22
38	18.2	8·58	Wilmington.	1·50	30·05				Calm.	S.W. 6
39	21.1	9·56	Galveston.	3·67	29·95				E. 5	Calm.
40	Sept. 19.2	11·39	Cape May.	1·92	·70	·57	S. 12 W.	487	E. 3	N.W. 8
41	19.3	8·96	Mt. Washington.	2·20	·86	·59	North.	202	S.W. 24	W. 12
42	24.1	9·51	Mt. Washington.	1·55	30·12	·86	N. 7 E.	222	W. 6	N.W. 12
43	28.1	8·69	Fort Gibson.	1·01	29·75				E. 7	S.E. 6
44	Oct. 19.3	9·82	New London.	2·25	·80	·52	N. 34 E.	329	S.E. 2	S.E. 24
45	20.1	17·65	Philadelphia.	1·96	·47	·45	N. 16 W.	89	E. 12	N. 12
46	20.2	12·27	Rochester.	1·38	·65	·26	N. 26 W.	273	N. 20	N.E. 25
47	20.3	9·86	Buffalo.	1·23	·35	·30	N. 54 W.	160	N. 23	N. 14
48	27.1	8·30	Knoxville.	1·24	·79	·29			N.W. 24	W. 25
49	27.2	8·68	Cape May.	0·90	·63	·22	S. 35 W.	410	S. 26	S.W. 4
50	Nov. 8.1	8·64	Boston.	1·75	·58	·48	N. 84 E.	225	E. 12	N.E. 17
51	18.1	8·23	Boston.	1·50	28·69	28·66	N. 48 E.	101	N.E. 28	W. 16
52	18.2	9·23	Sydney.	1·37	29·09	28·47	N. 75 E.	332	E. 10	S.E. 18
53	24.1	11·16	Nashville.	1·08	·86	29·49	S. 48 W.	520	Calm.	W. 8
54	24.2	14·69	New London.	2·80	·30	·27	S. 61 W.	90	S.E. 14	N. 12
55	27.2	9·71	Charleston.	1·75	·91				Calm.	N. 8

pressure expressed in English miles; column 11th shows the direction and force of the wind at the place mentioned in column 4th and at the date given in column 2d; and column 10th shows the direction and force of the wind at the observation next preceding the date mentioned in the table.

For each of the cases named in this table, the curves of equal rain-fall have been accurately drawn upon maps of the United States, and these curves have been carefully compared. The following table shows the geographical extent of some of these rain-areas. Column 1st shows the number of reference taken from the preceding table; column 2d shows in English miles the greatest and least diameters of the area over which the rain-fall was at least one inch in eight hours; and column 3rd shows the greatest and least diameters of the area over which the rain-fall was at least half an inch, in eight hours.

Dimensions of Rain-areas.

No.	Area of one inch rain.	Area of half inch rain.	No.	Area of one inch rain.	Area of half inch rain.	No.	Area of one inch rain.	Area of half inch rain.
10	720–230	920–398	17	443–167	714–393	20	338–173	890–406
9	605–334	668–430	16	440–160	858–356	54	338–194	458–358
45	546–318	724–350	27	380–296	468–390	7	320–288	394–312
39	490–183	514–236	32	374–150	796–340	5	312–276	394–394
55	468–162	652–312	6	360–304	440–402	11	300–174	494–300
31	446–216	774–332	8	354–144	436–266	18	242–162	858–224

The form of these rain-areas is sometimes quite irregular but generally it approximates to an ellipse of which the major axis is not quite double the minor axis. This elongated form of rain-areas is more noticeable in storms which prevail near the Atlantic coast, than it is in regions remote from the ocean. It will be seen that in three cases the area of one inch rain-fall exceeded 500 miles in length, and in six cases the area of one half inch rain-fall exceeded 750 miles in length. In number ten, the area of one quarter inch rain-fall was 1,180 miles by 500 miles; in number twenty, this area was 1,000 miles by 572 miles, and in two or three other cases the dimensions of the rain-areas were nearly as great. Frequently the entire rain-area is an oval figure whose length exceeds 1,000 miles, and whose breadth exceeds 500 miles.

It was shown in my sixth paper, that south of latitude 36° rain-areas are as frequently under the influence of an area of high barometer as of an area of low barometer. In columns 7, 8 and 9, of the table on page 2, I have therefore left blanks for the southern stations. The numbers in column 8th, for the northern stations, show that in seventeen cases the rain center was north of the center of low pressure, and in sixteen cases it was south of this center. In twenty cases the rain center was east of the center of low pressure, and in twelve cases it was west of this center. If, however, we consider the middle of the rain-fall as corresponding to a date four hours preceding the barometric observation, we shall find that in four of these cases, viz: numbers 1, 2, 14, and 54, the principal rain-fall occurred when the rain center was east of the center of low pressure, or at least very near it. In several of the cases, however, the rain center was clearly west of the center of low pressure, and in some of the cases the rain-fall apparently had a decided influence upon the direction of the storm's progress. This was specially true of numbers 45, 46 and 47, in which case the center of minimum pressure moved *westward* instead of eastward. As this example is a very remarkable one, I will consider it particularly.

On the morning of October 19th 1873, along the coast of North Carolina, Virginia and New Jersey, light winds from the east, or southeast generally prevailed, while west of Virginia and Pennsylvania the winds were generally from the west or northwest. This opposition of the winds was attended by a rain-fall, which in the afternoon became general along the Atlantic coast from Wilmington to Boston and extended inland 300 or 400 miles. The barometer fell steadily during the day, and a center of minimum pressure which had prevailed for twenty-four hours near the coast of Florida, advanced rapidly northward. During the evening of the 19th the same winds continued with increasing strength; the rain-fall increased especially about Washington and New London; the barometer continued to fall, and the center of minimum pressure advanced to Norfolk. On the morning of the 20th the same system of winds prevailed but had advanced further northward, the southeast winds near the coast extending from New York to Nova Scotia, and having a velocity of twelve to twenty-five miles, and were opposed by fresh winds from the north and west in the vicinity of Lakes Erie and Ontario. At Quebec the wind blew from the east, forty-six miles per hour, and on Mt. Washington the wind blew from the southeast seventy-five miles per hour. The total rain-fall at all the stations during the preceding eight hours was greater than was recorded for any other equal period during the fifteen months under discussion. The center of minimum pressure had now reached Cape May, and the center of the rain area was 250 miles further north. During the 21st the system of east winds near the coast of New England and Nova Scotia had pushed further into the interior, and in the afternoon extended to Rochester, which was now the center of greatest rain-fall, while the center of minimum pressure moved slowly in the same direction. The wind at Quebec still blew from the east, forty-two miles per hour, and on Mt. Washington it blew from the southeast, seventy-eight miles per hour. During the evening of the 20th the same system of winds continued, but the center of the rain-area was at Buffalo, and the center of minimum pressure advanced in the same direction. The wind at Quebec still blew from the east forty-five miles per hour, and on Mt. Washington from the southeast fifty miles per hour. On the morning of the 21st, southerly and easterly winds extended from the coast of New England to Lake Erie, where was now the greatest rainfall, and also the center of minimum pressure. At Grand Haven on Lake Michigan, the wind blew from the north thirty-two miles per hour, and on Mt. Washington from the southeast fifty-five miles per hour. On the afternoon of the 21st the system of winds was nearly the same, but their intensity was sensibly diminished. On Mt. Washington the wind blew from the southeast thirty-eight miles per hour. The center of minimum pressure had now advanced westward nearly to Lake Michigan, a result which was apparently due to a second area of low pressure which came from the northwest and coalesced with the one which we have been considering. During the evening of the 21st the easterly motion of the winds near the coast of New England was very much diminished; the rainfall was also diminished, and the center of minimum pressure advanced a little to the north. On the morning of the 22d the rain-fall had nearly ceased, the winds were generally moderate, and the center of minimum pressure moved a little toward the north east. During the 22d there were two centers of maximum pressure in the southern part of the United States, and under their influence southerly winds generally prevailed east of the Mississippi, while in the northwestern States the winds were from the northwest. Hence resulted a circulation of the winds about Lake Superior, and the center of minimum pressure moved in that direction. On the 23d the pressure in the southern States increased; southerly winds generally prevailed throughout the Lake region, and the center of minimum pressure was apparently pushed still further toward the northwest, but as this center had now passed beyond the stations of observation, it is impossible to locate it with precision.

Plate I shows the curves of equal rain-fall for October 20, 7.35 A. M. The outer curve shows the extreme limits of the rain-area during the preceding eight and one-half hours; the next curve shows the limit of one half inch rain-fall; the third curve shows the area over which the rain-fall was at least one inch; and the inner curve shows the area of one and a half inch rain-fall. At Philadelphia and Burlington the rain-fall was 1·96 inch during the eight and one-half hours, and it is probable that near the center of the rain area the rain-fall exceeded two inches. The successive positions of the center of minimum pressure are indicated by the figures 19·2, 19·3, 20·1, etc., and the undulating line connecting these points represents the path of the center of minimum pressure from October 19th to October 22d. The arrows at the several stations represent the direction of the winds for October 19th, 11 P. M., which was the time of commencement of the rain-fall represented upon the map.

This example presents a very unusual case of a storm center traveling for several days toward the northwest. This result was apparently produced by a wind of unusual violence setting in from the Atlantic Ocean, and meeting with opposing winds from the interior caused a very unusual rain-fall, and the center of minimum pressure followed the center of the rain-area. These facts seem to indicate that a heavy rain-fall extending over a large area has a decided influence in determining the course of a storm center.

In No. 26 the principal rain-fall was on the northwest side of the center of minimum pressure but not over 150 miles from it. In No. 53 the principal rain-fall was on the southwest side of the center of minimum pressure, and these two cases, together with No. 12 on page 15 of my last paper, indicate that in the neighborhood of Kentucky it is not uncommon for the principal rainfall to occur after the center of low pressure has passed eastward.

In Nos. 40 and 49 the rain-fall at Cape May was greater than at any other station, but there was at the same time another rain-area of much greater extent near the center of minimum pressure. The rain-fall at Cape May was apparently the result of a local cyclone which did not greatly affect the height of the barometer.

In No. 19 there was a center of low pressure in Nova Scotia, but it seemed to have little influence upon the winds near Philadelphia. There was a center of high pressure in Iowa, and the winds near the Lake region were generally from the northwest. At Norfolk the wind was from the south, and a new center of low pressure was forming near the coast of North Carolina. The rain about Philadelphia on the morning of January 17th was apparently due to a local cyclonic movement, more than to the influence of the low center in Nova Scotia.

The average distance of the center of greatest rain-fall from the center of low pressure for cases north of latitude 36°, is 300 miles, but it sometimes exceeds 750 miles.

In 19 cases the distance was less than 250 miles.
11 " " between 250 and 500 miles.
5 " " " 500 and 750 miles.
3 " " over 750 miles.

In No. 34 (page 2) there was a center of low pressure in Minnesota, but it seemed to exert no control over the winds in the eastern and southern parts of the United States. Here there were five centers of local cyclonic movement, each of which became the center of a rain-area as shown on Plate II. Neither of these centers became a center of low pressure although the rain-area near Washington continued for sixteen hours.

In No. 10 there was a center of low pressure over Lake Superior, but this was so distant that it exerted but little influence over the winds near the Atlantic coast. On the evening of November 6th, winds from the south and east generally prevailed along the entire Atlantic coast, and these being opposed by westerly winds (the result of a high barometer in Tennessee), there was an extensive rain on the night of November 6th, which was especially heavy along the coast from Georgia to Massachusetts. This rain-fall seemed to have a decided influence in accelerating the movement of the center of low pressure, as was mentioned in my last paper, p. 16.

No. 15 was in many respects similar to No. 10, but it did not produce the same effect on the movement of the low center, perhaps owing to the influence of another rain-area which prevailed near Montreal.

No. 19 has already been referred to; see preceding page.

In No. 32 the center of lowest pressure was beyond Lake Superior, but the barometer was quite low (29·56) at Port Stanley, and here there was apparently a local cyclone resulting in a heavy rain-fall.

No. 30 shows the influence of an area of high pressure combined with an area of low pressure. On the 7th of May there was an area of low pressure near the mouth of the Ohio River, and an area of high pressure in New England, which gave rise to a system of southeast winds along the Atlantic coast, and extending to the Lake region. The result was a slight rain-fall over a large area of territory, but the rain was greatest about Lynchburg, near which place there was some evidence of cyclonic motion. Perhaps the Alleghany Mountains had some influence in determining the upward movement of the southeast current near this place.

No. 22 appears to have resulted from east winds along the Atlantic coast opposed by west winds near the Mississippi valley, on the south side of an area of low pressure.

No. 53 has already been referred to on page 6, and it is remarkable that the center of low pressure moved towards the northeast at the rate of 54 miles per hour, leaving the center of principal rain-fall almost exactly in its rear. There were, however, at the same time two other rain areas of considerable extent on the northeast side, one about Baltimore and the other about Montreal.

From the preceding statement we perceive that in the United States, south of latitude 36°, great rain-falls are accompanied by a cyclonic movement of the air which sometimes appears to be the result of a neighboring area of low pressure, and sometimes of an area of high pressure, and the latter case is about as frequent as the former. North of latitude 36° rain-areas are most frequently associated with areas of low barometer and generally they are found on the east side of the center of low pressure; but occasionally they are found on the west side of the center of low pressure, and this case occurs most frequently in the neighborhood of the Ohio valley. Extensive rain-areas sometimes occur in the Northern States at a great distance from a low center, where they appear to be as much under the influence of a center of high pressure as of a center of low pressure, and in these cases there are generally indications of a local cyclonic movement of the atmosphere.

Of the fifty-five cases enumerated in the table on page 2, in thirty-eight cases the wind blew from some quarter between northeast and southeast, either at the date given in the table or at the time of the preceding observation. Of the seventeen remaining cases, in five of them the air was reported as *calm*; in three of them the wind was from the south, and two of the cases occurred on the summit of Mt. Washington. In one of the remaining cases the velocity of the wind was only two miles per hour; in another case the velocity was three miles per hour; in a third case it was seven miles per hour, and in a fourth case it was nine miles per hour. There remain only three cases in which at both the observations the wind was strong from some quarter between north and southwest. These cases are Nos. 19, 47 and 48.

In No. 19, the winds upon the Atlantic coast near Philadelphia were generally from the south or southeast, while at a distance of 300 miles from the coast, the winds were from the west or northwest. It seems probable that this northwest current crowded under the southeast current lifting it up from the earth's surface and thus condensing its vapor, and that the south wind at Philadelphia was the result of the meeting of the southeast wind from the ocean with the northwest wind of the interior.

In No. 47, as has been already mentioned on page 4, the center of the rain-area was on the northwest side of the center of low pressure. It seems probable that in this case the violent southeast wind from the ocean extended further west than Buffalo, and that its vapor was condensed by its being elevated from the earth's surface by the crowding of the northwest wind beneath it. This fact is distinctly indicated by the following observations for October 20th, 7.35 A. M., from stations west of the limits of the rain area.

	WIND.		Direction of upper clouds.	Amount of clouds.
	Direction.	Velocity.		
Alpena	North.	9 miles.	S.W.	$\frac{3}{4}$
Detroit	North.	12 "	South.	$\frac{3}{4}$
Louisville	North.	16 "	South.	$\frac{1}{4}$
Toledo	North.	15 "	S.E.	$\frac{3}{4}$

In No. 48, south winds generally prevailed in Georgia and the Carolinas, with cold winds from the west and northwest in the Northwestern States. This westerly current probably pushed under the south wind from the ocean and lifting it up from the earth's surface condensed its vapor, and it is presumed that this south wind prevailed as an upper current at many places where the northwest wind prevailed at the surface. We thus see that during heavy rain-falls the wind generally blows from some quarter between south and northeast, or if it blows from any other quarter its velocity is quite small; but occasionally a great rain-fall occurs with a strong wind from some quarter between north and southwest and in such cases it is presumed that at the same time an easterly wind prevails at those places as an upper current. This upper current from the east is generally concealed by the lower clouds whose motion is nearly the same as that of the surface wind; but when the lower clouds are broken, the movement of this upper current can sometimes be seen.

The average velocity of the wind at the date of the observations in the table on page 2, was ten miles per hour, and at the date of the preceding observations it was eleven miles per hour; and in only six cases did the velocity rise as high as twenty-five miles per hour, either at the date given in the table or at the preceding observation. Thus we see that the heaviest rain-falls are seldom accompanied by very high wind.

One of the most noticeable facts connected with extensive rain-falls is the tendency to the formation of several centers of precipitation. If in each of the cases mentioned in the table on page 2 we trace the boundary of that area over which the rain-fall was at least one inch, we shall find that in half of these cases there were two such areas distinct from each other, and in eleven cases there were three such areas. If we trace the area of a rain-fall of at least one-half inch, we shall find that in forty-five cases there were at least two distinct rain-areas, and in twenty-nine cases there were three or more such areas. If we trace the area of a rain-fall of one-fourth inch or more, we shall find that there are only three cases, viz:

Nos. 8, 24, and 45, in which there were not at least two distinct rain-centers. In No. 45 there was apparently a subordinate rain-center, near Charleston, and in No. 8 there was a fall of 0·14 inch at Alpena, which was beyond the principal rain-area. Thus we see that when there is an extensive rain-fall in the United States there is almost invariably more than one center of precipitation, and this fact suggests the idea that those conditions which are favorable to rain-fall at one locality, are generally favorable to rain-fall over a much larger district, and this often results in a simultaneous precipitation at several points remote from each other.

Plate II exhibits the rain-areas for July 27th, 1873, at 4.35 P. M. Here we find four rain-areas showing a rain-fall of at least one inch, and an equal number of areas showing a smaller rain-fall. The following table shows the greatest amount of rain observed at any station within each of these areas:

Rain-fall July 27, 1873, 4.35 P. M.

Washington	2·12	inches.	**Shreveport**	0·84	inch.
New York	1·54	"	**Breckenridge**	·45	"
Nashville	1·35	"	**Wilmington**	·18	"
Eastport	1·00	"	**Denver**	·09	"

It is possible that the Washington rain area was not entirely distinct from the New York area, but the observations clearly indicate two centers of greatest rain-fall. During the time of this rain-fall, the barometer was a little above 30 inches at all of the stations here mentioned, except Breckenridge. The arrows show the direction of the wind at 4.35 P. M. There were decided local cyclones near Washington, New York, and Nashville, and indications of opposing winds near Shreveport and Breckenridge. It is presumed that if the stations had been sufficiently numerous, the same fact would have been established for each of the rain-areas. As the largest of these cyclonic areas had a diameter less than a 1,000 miles, and the velocity of the winds was almost everywhere less than ten miles per hour, no perceptible effect was produced upon the barometer.

A considerable number of the cases mentioned in the table on page 2, exhibit a variety of rain-areas nearly as remarkable as that shown in Plate II. Among these may be mentioned Nos. 1, 2, 3, 12, 14, 33, 36, and 41.

In order to determine the duration of great rain-falls, I selected all those cases in which any of the rain-falls mentioned in the table on page 2, were followed by at least four inches of rain (total amount at the eighty stations) during a succeeding period of eight hours. The following table shows the result of this comparison.

Heavy Rain (four inches aggregate in eight hours) continuing more than eight hours.

Date.	Total rain-fall.	Station of greatest rain.	Date.	Total rain.	Station.	Date.	Total rain.	Station.	Date.	Total rain.	Station.	Date.	Total rain.	Station.	Date.	Total rain.	Station.
1872.																	
Sept. 11.3	10·76	Marquette.[1]	12.1	4·02	Grand Haven[2]	12.2	9·93	Saugeen.[3]									
Oct. 6.3	8·75	Vicksburg.	7.1	5·91	Pittsburg.	7.2	8·58	Montreal.	7.3	6·05	Norfolk.						
22.3	8·30	Jacksonville.[1]	23.1	9·34	Jacksonville.[2]	23.2	4·45	Charleston.[3]									
25.1	8·91	Norfolk.[1]	25.2	7·09	New York.[2]	25.3	5·03	Pittsburg.[3]	26.1	8·80	Philadelphia.[4]	26.2	5·77	Mt. Wash'ton.[5]			
Nov. 6.3	9·91	Montgomery.	7.1	13·52	New York.[1]	7.2	6·27	New London.[2]									
Dec. 20.1	14·49	New York.[1]	20.2	5·31	Boston.[2]												
26.1	9·46	Norfolk.[1]	26.2	6·10	Philadelphia.[2]												
1873.																	
Jan. 2.2	9·12	Keokuk.	2.3	6·37	Port Stanley.[1]	3.1	8·63	New York.[2]									
5.1	12·74	Lake City.	5.2	16·25	Philadelphia.												
16.1	10·08	New Orleans.	16.2	6·23	Detroit.	16.3	4·95	Lynchburg.[1]	17.1	8·05	Philadelphia.[2]						
Feb. 16.1	10·57	Louisville.[1]	16.2	9·87	Cape May.[2]												
Mar. 29.1	10·65	Lake City.	29.2	10·48	Oswego.[1]	29.3	5·80	Rochester.[2]									
April 8.1	8·70	Indianapolis.[1]	8.2	8·57	St. Louis.[2]	8.3	4·48	Nashville.[3]									
May 1.2	9·37	Montgomery.	1.3	7·95	New Orleans.	2.1	11·78	Wilmington.[1]	2.2	8·49	Wilmington.[2]	2.3	4·46	Boston.	3.1	4·58	Pittsburg.
8.1	8·33	Lynchburg.[1]	8.2	7·14	Washington.[2]	8.3	4·89	Cape May.[3]	9.1	7·88	Indianola.	9.2	7·98	New London.	9.3	4·44	Grand Haven.
June 30.2	9·23	Port Stanley.[1]	30.3	5·23	Oswego.[2]	1.1	4·95	Denver.									
July 27.2	9·63	Washington.[1]	27.3	7·31	Philadelphia.[2]												
Aug. 13.1	9·52	Philadelphia.[1]	13.2	8·27	Philadelphia.[2]	13.3	7.81	Baltimore.[3]	14.1	7.42	Breckenridge.	14.2	5·89	Boston.[1]	14.3	4·61	Portland,[2] Me.
															[15.1	4·25	Denver.
21.1	9·56	Galveston.[1]	21.2	7·06	Mobile.[2]												
Sept. 19.2	11·39	Cape May.[1]	19.3	8·96	Mt. Wash'ton.[2]	20.1	6·32	Wilmington.									
28.1	8·69	Fort Gibson.[1]	28.2	6·28	Fort Gibson.[2]	28.3	4·27	Chicago.[1]	29.1	7·65	Alpena.[2]						
Oct. 19.3	9·82	New London.[1]	20.1	17·65	Philadelphia.[2]	20.2	12·27	Rochester.[3]	20.3	9·86	Buffalo.[4]	21.1	5.90	Cleveland.[5]			
27.1	8·30	Knoxville.	27.2	8·68	Cape May.												
Nov. 8.1	8·64	Boston.[1]	8.2	5·09	Eastport.[2]												
18.1	8·23	Boston.	18.2	9·23	Sydney.												
24.1	11·16	Nashville.	24.2	14·69	New London.												

We thus see that in a period of fifteen months there were twenty-six cases in which a total rain-fall of eight inches in eight hours was followed by a total rain-fall of more than four inches in the next eight hours; there were sixteen cases in which it was followed by a similar rain-fall for a third period of eight hours; there were eight cases of a fourth period of eight hours; five cases of a fifth period; three cases of a sixth period; and one case of a seventh period of eight hours. These rain-areas which succeeded each other in order of time, were not, however, in all cases apparently connected with each other; that is, they were not continuous rain-areas, or even adjacent to each other. Those cases which were apparently thus connected, I have indicated by the numerals 1, 2, 3, etc., attached to the names of the stations. It must not be inferred that these rain-areas had in all cases a proper movement of translation in the direction of the stations here indicated. In some cases this apparent movement resulted from a slight increase of precipitation in one part of an extensive rain-area, and a decrease in some other part. This remark will probably explain two or three of the cases in which the apparent movement of the rain-area was from east to west. In one case however, viz: October 19th, 1873, the rain-area did unquestionably advance westward for forty-eight hours as shown on page 4. The average rate of motion of the rain-areas indicated by numerals in the table, is 20·7 miles per hour.

This table shows that great rain-areas are seldom of long continuance. In twenty-three cases the same rain-area continued for at least two periods of eight hours; in seven cases it continued for at least three periods; and in only two cases did it continue for more than three periods, that is, twenty-four hours. We thus see that rain-areas with a total rain-fall of at least four inches in eight hours, for eighty stations, seldom continue for more than twenty-four hours, only two or three such cases occurring in the United States during a year. This fact seems to indicate that the causes which produce rain, instead of deriving increased force from the rain-fall, rapidly expend themselves and become exhausted. This fact cannot be explained by supposing that the vapor of the air has all been precipitated, because these cases chiefly occur near the Atlantic coast, where the wind which supplies the vapor comes from the ocean, and the supply is therefore inexhaustible. The facts seem rather to indicate that the forces which impart that movement to the air which is requisite to a precipitation of its vapor, become exhausted after a few hours exercise.

Of the fifty-five cases included in the table on p. 2, in twenty-seven cases the place of greatest rain-fall was on the Atlantic coast. But only one-fifth of all the stations are on the Atlantic coast; that is, the center of great rain-areas is found near the Atlantic coast *four times* as frequently as it is in the other portions of the United States. The center of great rain-areas is not found in the neighborhood of the great Lakes more frequently than it is at inland stations quite distant from the Lakes.

The distribution of these fifty-five cases by seasons was as follows;

Spring 8; Summer 9; Autumn 10 and 16; Winter 12;

showing a slight predominance of great rain-areas in autumn and winter. In my last paper it was shown that excessive rains at single stations were most common during the warmest months; but it appears that very extensive rain-falls are most common during the cooler months.

The distribution of these cases according to the hour of the day was as follows:

7.35 A. M. 25 cases; 4.35 P. M. 22 cases; 11 P. M. 8 cases.

After correcting these numbers for the inequality of the time intervals, we still find that from 4.35 to 11 P. M. great rain-falls are *not half as frequent* as during the remainder of the day. This result is quite similar to that found in my last paper with regard to great rain-falls at single stations south of latitude 36°. It is essential to the accuracy of this conclusion that the record in each case should show the actual rain-fall since the preceding observation. There are a few cases in which the last column of the record reports *heavy rain*, but the rain-column makes no mention of rain. It is presumed that generally in these cases the rain had but recently commenced, and the observer thought it would be equally satisfactory to report the entire rain-fall at the time of the next observation. There seems no reason to question the conclusion which these numbers indicate, viz: that the causes which produce excessive rain-falls in the United States, act with less intensity in the evening than during the remainder of the day.

Areas of low pressure without rain.

In order to compare the influence of a very small rain-fall with that of a very great rain-fall, I selected all those cases during a period of fifteen months (September, 1872 to November, 1873) in which the rain-fall did not amount to one-tenth of an inch in eight hours at any of the stations. The following table exhibits these cases. Column 1st contains the number of reference; column 2nd shows the day and hour of observation; column 3d shows the total rain-fall for the preceding eight hours at all the stations. In September, 1872, the num-

Rain-fall less than one-tenth of an inch in eight hours at any station.

No.	Date.	Total rain-fall.	Low Bar.	Station.	Low moved		Rain in Low.	High Bar.	Station.
					Direction.	Vel.			
	1872.								
1	Sept. 2.3	0·04	29·65	Fort Sully.	*	0	0·00	30·25	Marquette.
2	3.1	·06	·67	Fort Sully.	East.	4	·01	·26	Escanaba.
3	14.2	·02	·71	Fort Sully.	East.	22	·00	·30	Saugeen.
4	14.3	·02	·66	Fort Sully.	East.	6	·00	·29	Toronto.
5	15.1	·06	·84	Duluth.	East.	28	·00	·35	Kingston.
6	20.3	·04	·63	Leavenworth.	N. 41 E.	15	·00	·23	Augusta.
7	21.3	·07	·77	Chicago.	*	0	·04	·22	Wilmington.
8	Oct. 1.2	·33	·67	Fort Sully.	N. 69 E.	24	·00	·22	Nashville.
9	1.3	·07	·86	Duluth.	N. 69 E.	24	·00	·27	Nashville.
10	4.2	·12	·68	Keokuk.	East.	7	·03	·07	Jacksonville.
11	5.1	·14	·82	Escanaba.	N. 18 E.	22	·05	·35	Portland, Me.
12	8.3	·13	·71	Marquette.	East.	17	·00	·21	Lynchburgh.
13	11.2	·04	·82	Fort Sully.	?	?	·00	·30	Cincinnati.
14	11.3	·00	·82	Duluth.	East.	15	·00	·30	Cincinnati.
15	12.1	·00	·71	Marquette.	East.	17	·00	·30	Lynchburgh.
16	12.2	·10	·69	Alpena.	S. 67 E.	24	·01	·15	Portland, Me.
17	14.3	·08	·59	Breckenridge.	N. 62 E.	42	·00	·24	Vicksburg.
18	15.1	·05	·49	Escanaba.	S. 68 E.	33	·05	·24	Knoxville.
19	15.2	·29	·47	Grand Haven.	S. 36 E.	30	·29	·15	Savannah.
20	15.3	·24	·53	Saugeen.	N. 86 E.	29	·24	·21	Augusta.
21	16.3	·08	·83	Fort Sully.	N. 82 E.	47	·00	·34	Philadelphia.
22	19.3	·03	·86	Omaha.	N. 54 E.	5	·00	·27	Cincinnati.
23	20.1	·00	·80	Omaha.	N. 52 E.	4	·00	·32	Nashville.
24	20.2	·00	·60	Breckenridge.	N. 47 E.	5	·00	·25	Norfolk.
25	20.3	·01	·58	Marquette.	N. 55 E.	45	·00	·27	Norfolk.
26	21.1	·07	·62	Escanaba.	S. 77 E.	15	·00	·32	Norfolk.
27	21.2	·10	·77	Milwaukee.	S. 16 E.	11	·00	·28	Norfolk.
28	31.2	·00	·77	Escanaba.	East.	?	·00	·24	Nashville.
29	Nov. 15.2	·39	·59	Quebec.	East.	?	·23	·67	Fort Benton.
30	15.3	·28	·75	Quebec.	East.	?	·15	·58	Fort Benton.
31	16.3	·16	·96	Quebec.	East.	?	·02	·65	Nashville.
32	17.3	·06	30·11	Alpena.	East.	?	·00	·71	Leavenworth.
33	21.1	·07	29·69	St. Paul.	S. 58 E.	36	·05	·44	Lynchburgh.
34	21.2	·05	·73	Alpena.	East.	35	·05	·30	Cape May.
35	21.3	·09	·76	Escanaba.	East.	6	·06	·24	Lynchburgh.
36	23.2	·10	·70	Denver.	S. 32 E.	15	·00	·42	Mobile.
37	27.3	·02	·91	Quebec.	East.	?	·02	·64	Breckenridge.
38	28.1	·00	30·09	Escanaba.	?	?	·00	·71	Breckenridge.
39	30.3	·17	29·32	Pembina.	East.	18	·16	·36	Jacksonville.
40	Dec. 3.3	·18	·99	Fort Sully.	East.	10	·00	·47	Nashville.
41	4.1	·11	·94	Fort Sully.	East.	14	·00	·51	Nashville.
42	4.2	·07	30·03	St. Paul.	S. 86 E.	42	·00	·38	Cincinnati.
43	6.2	·13	·04	Fort Sully.	East.	?	·00	·45	Davenport.
44	6.3	·04	·00	Fort Sully.	East.	?	·00	·41	Davenport.
45	7.1	·09	29·67	Pembina.	N. 49 E.	31	·05	·39	Memphis.
46	14.2	·11	·59	Milwaukee.	N. 73 E.	48	·06	·47	Breckenridge.
47	14.3	·22	·73	Alpena.	N. 69 E.	37	·12	·44	Omaha.
48	31.3	·43	·67	Santa Fe.	East.	14	·01	·43	Davenport.
	1873.								
49	Jan. 10.2	·13	·82	Montreal.	East.	?	·00	·62	Memphis.
50	11.3	·08	·55	Fort Sully.	S. 74 E.	15	·08	·57	Augusta.

Table continued.

No.	Date.	Total rain-fall.	Low Bar.	Station.	Low moved		Rain in Low.	High Bar.	Station.
					Direction.	Vel.			
	1873.								
51	Jan. 12.3	0·16	29·73	Milwaukee.	S. 88 E.	50	0·08	30·56	Boston.
52	19.2	·39	·43	Fort Garry.	S. 72 E.	13	·07	·28	Mobile.
53	19.3	·20	·41	Fort Garry.	S. 81 E.	14	·13	·27	Mobile.
54	Feb. 1.1	·19	·65	San Francisco.	East.	18	·00	·95	Fort Sully.
55	1.3	·07	·67	San Francisco.	East.	13	·02	·74	Davenport.
56	9.1	·33	·57	Quebec.	East.	?	·11	·51	Vicksburg.
57	10.1	·08	·50	Fort Garry.	East.	27	·00	·50	Washington.
58	10.2	·08	·43	Escanaba.	East.	36	·06	·41	Savannah.
59	17.3	·10	·38	Omaha.	N. 76 E.	46	·10	·29	Oswego.
60	23.2	·32	·63	Corinne.	?	?	·00	·24	Fort Sully.
61	25.2	·25	·32	Denver.	S. 62 E.	14	·10	·16	Chicago.
62	28.2	·32	·77	Cheyenne.	East.	5	·11	·38	Cleveland.
63	Mar. 5.2	·10	·51	Virginia City.	East.	?	·08	·66	Kingston.
64	5.3	·00	·42	Virginia City.	East.	?	·00	·72	Baltimore.
65	6.1	·03	·45	Fort Benton.	East.	?	·02	·78	Lynchburgh.
66	13.1	·02	·92	Fort Benton.	?	?	·00	·42	Nashville.
67	13.2	·03	·58	Virginia City.	East.	20	·01	·33	Savannah.
68	13.3	·02	·79	Corinne.	East.	20	·00	·40	Savannah.
69	16.3	·04	·68	Santa Fe.	East.	7	·03	·40	Cincinnati.
70	22.2	·10	·64	Omaha.	East.	32	·00	·30	Fort Sully.
71	22.3	·01	·66	Marquette.	East.	32	·00	·47	Fort Sully.
72	27.3	·05	·41	Omaha.	S. 50 E.	42	·00	·36	Norfolk.
73	April 4.1	·08	·31	Yankton.	East.	7	·03	·26	Kingston.
74	4.3	·05	·50	Leavenworth.	East.	5	·01	·36	Kingston.
75	21.2	·08	·45	Leavenworth.	S. 29 E.	29	·00	·26	San Francisco.
76	May 16.1	·09	·58	Santa Fe.	?	?	·07	·16	Duluth.
77	June 20.2	·23	·60	Fort Sully.	?	?	·00	·13	Mobile.
78	July 6.3	·04	·78	Omaha.	East.	5	·00	·12	Denver.
79	12.3	·12	·48	Breckenridge.	S. 50 E.	13	·10	·29	New London.
80	21.3	·17	·39	Fort Garry.	N. 39 E.	9	·02	·19	Lynchburgh.
81	Sept. 11.3	·09	·62	Marquette.	East.	7	·02	·29	Fort Benton.
82	21.1	·30	·76	Fort Garry.	East.	13	·04	·34	Washington.
83	Oct. 2.2	·06	·79	Havannah.	?	?	·01	·27	Marquette.
84	2.3	·06	·83	Havannah.	?	?	·00	·32	Marquette.
85	9.2	·00	·49	Fort Garry.	?	?	·00	·34	Chatham.
86	9.3	·08	·58	Fort Garry.	East.	?	·02	·36	Chatham.
87	10.2	·04	·68	Fort Garry.	?	?	·00	·35	Corinne.
88	10.3	·02	·86	Duluth.	East.	?	·00	·34	Cheyenne.
89	12.3	·23	·51	Fort Garry.	East.	19	·00	·39	Portland, Or.
90	13.3	·15	·87	Alpena.	East.	?	·00	·31	Wilmington.
91	14.2	·11	·66	Yankton.	N. 71 E.	25	·01	·34	Wilmington.
92	14.3	·02	·72	Fort Sully.	N. 71 E.	6	·02	·44	Saugeen.
93	15.3	·03	·95	St. Paul.	East.	20	·00	·52	Cape May.
94	30.1	·30	·71	Duluth.	S. 69 E.	27	·21	·48	Philadelphia.
95	Nov. 9.3	·16	·38	Cape Rozier.	?	?	·02	·36	Corinne.
96	10.1	·02	·48	Farther Point.	?	?	·00	·38	Corinne.
97	10.2	·09	·87	Fort Sully.	?	?	·00	·34	Corinne.
98	13.3	·18	·61	Virginia City.	N. 77 E.	25	·00	·23	Portland, Or.
99	14.1	·17	·43	Fort Garry.	N. 77 E.	25	·00	·36	Portland, Or.
100	14.2	·17	·41	Fort Garry.	N. 77 E.	25	·09	·34	Portland, Or.
101	16.1	·11	·33	Oswego.	S. 79 E.	29	·11	·46	Corinne.

ber of stations was seventy-two, but this number was gradually increased and in November, 1873, amounted to eighty-eight. Column 4th shows the height of the barometer at the nearest center of minimum pressure; column 5th shows the station at which the pressure given in column 4th was observed; column 6th shows the direction in which the low center had moved during the last eight hours, and column 7th shows the velocity with which it moved expressed in miles per hour. Column 8th shows the total amount of rain observed within the area of low barometer; that is, at the stations where the pressure was less than thirty inches. Frequently there was at the same time a second center of low pressure near the borders of the United States, but columns 4–8 refer exclusively to the first center; column 9th shows the height of the barometer at the center of maximum pressure, and column 10th shows the station at which this high pressure was observed. Frequently there was at the same time more than one center of high pressure within the limits of the United States, but columns 9 and 10 refer to that which was regarded as the principal center.

This table shows that barometric minima frequently occur with very little rain. Of the 101 cases here mentioned, more than half showed a pressure less than 29·70; more than one-third were below 29·60, and nearly one-quarter of the cases were below 29·50. The average pressure at the stations of greatest rain-fall mentioned in the table on page 2, was 29·74, and the average pressure at the center of the low barometer attending these remarkable rain-falls was 29·47.

It may be urged that these cases of minimum pressure generally occurred in that region where the stations of observation were widely separated, and that rain may have occurred at intermediate points where there was no observer. There is, however, a considerable number of cases in which the area of low barometer included a large number of stations. In about half of the cases there were at least twenty stations which showed a pressure below thirty inches; in one-third of the cases there were at least thirty stations which showed a pressure below thirty inches; and in several cases there were over fifty stations which showed a pressure below thirty inches. The following table contains the most important examples. Column 1st shows the number of reference from the preceding table and column 2nd shows the number of stations at which the barometer was below thirty inches.

There seems to be no room for doubt that barometric minima sometimes form with little or no rain, and continue without any considerable rain for eight hours, and sometimes for twenty-four hours or longer. These barometric minima seldom continue stationary for eight hours, but almost invariably

Number of stations within the area of low barometer.

No.	Stations	No.	Stations	No.	Stations	No.	Stations	No.	Stations	No.	Stations
75	70	60	47	35	43	74	39	16	32	59	30
101	67	39	45	7	43	100	39	24	31	61	30
77	58	70	45	17	42	58	35	36	31	90	30
19	53	53	44	18	42	73	34	11	30		
76	51	34	44	10	41	39	34	27	30		
20	48	52	43	71	39	6	33	29	30		

travel to the eastward. In several cases the center of least pressure was beyond the limits of the United States so that it is impossible to assign satisfactorily either the direction of their progress or their rate of motion. The table on pages 14 and 15 shows the best results I have been able to deduce from the observations. The average of all these directions is a little north of east, and the average velocity is 20·7 miles per hour. This direction is not quite as northerly as that given in my third paper for barometric minima generally, and the velocity is twenty per cent less.

In order to show more clearly the movement of the barometer during these periods of small rain-fall, I have represented upon Chart III the iso-baric curves for one of these periods, viz: October 19–21, 1872. The most western oval represents the isobar 29·8 for October 19th; the next curve represents the isobar 29·6 for October 20th; and the most eastern curve represents the isobar of 29·8 for October 21st; each of the curves corresponds to the 4.35 P. M. observation. It will be seen that during the first twenty-four hours, the center of least pressure moved only about five miles per hour; but during the next twenty-four hours the average motion was twenty-two miles per hour. During these forty-eight hours not a drop of rain was recorded at any station within the area of a pressure less than thirty inches, although on the 20th of October this area had a diameter of 1,500 miles.

The observations on the amount of cloudiness at the different stations confirm the observations of rain-fall. The following table presents a summary of these observations. Column 2d shows the number of stations within the area of low barometer (i. e., less than thirty inches pressure) at which the sky was reported to be entirely clear at the dates given in column 1st, except that the air was very generally reported to be *smoky* or *hazy*; column 3d shows the number of stations at which the sky was partly cloudy; and column 4th shows the number of stations at which the sky was entirely overcast.

The following are the stations at which the sky was reported to be overcast, viz: October 19.2, Virginia City and Duluth; 20.2, Corinne, Cheyenne and Duluth; 20.3, Denver, Cheyenne

	No clouds.	Partly cloudy.	Entirely overcast.
Oct. 19.2	5 stations.	2 stations.	2 stations.
19.3	8 “	2 “	none.
20.1	9 “	5 “	none.
20.2	13 “	7 “	3 stations.
20.3	15 “	3 “	3 “
21.1	5 “	7 “	3 “
21.2	4 “	9 “	5 “

and Duluth; 21.1, St. Paul, Duluth and Escanaba; 21.2, Santa Fe, Duluth, La Crosse, Keokuk and Toronto. Six of these cases occurred in the neighborhood of the Rocky Mountains, so remote from the center of least pressure that if there had been a rain-fall in that vicinity, it could not be supposed to be the cause of the barometric minimum under discussion. The long continuance of clouds at Duluth, and the extension of this cloud area on the 21st indicates an upward movement of the atmosphere attended with a slight precipitation of vapor, and there may have been rain-fall at places further north. But when we consider that in the Southern States a heavy rain-fall covering an area several hundred miles in diameter exerts scarcely any appreciable influence on the barometer, we cannot suppose that the very limited rain-fall which may possibly have occurred from October 19th to the 21st had any sensible influence in the production of the barometric minimum, or in causing its eastern progress, so that it seems safe to conclude that *rain-fall is not essential to the formation of areas of low barometer, and is not the principal cause of their formation or of their progressive motion.*

The barometric minimum October 19th, appears to have resulted from an area of high barometer (30·35) in the neighborhood of the Ohio valley combined with an area of high barometer (30·29) in Oregon. This excess of barometric pressure on opposite sides caused a general movement of the intermediate atmosphere towards the valley of the upper Missouri, and each of these currents being deflected to the right by the earth's rotation the result was a diminution of pressure over the region between the Rocky Mountains and Lake Superior. These two areas of high barometer on opposite sides of the low area were remarkably persistent from October 19th to 21st, but advanced eastward at about the same rate as the barometric minimum. Plate III, shows the direction of the winds October 20th, 4.35 P. M. They indicate a decided inward movement of the air and a circulation about the center of low pressure. At several of the stations the winds were uncommonly strong. The following table shows the direction and force of the wind where the velocity was greatest.

	Direction.	Velocity.		Direction.	Velocity.
Fort Sully	N.W.	36 miles.	Davenport	S.W.	18 miles.
Duluth	N.E.	28 "	Leavenworth	S.	18 "
Chicago	S.	23 "	Escanaba	S.E.	16 "
Grand Haven	S.	19 "	Omaha	S.	16 "

The distribution of the cases of small rain-fall mentioned in the table on pages 14 and 15, according to the seasons of the year, is as follows:

Spring, 14 cases. Summer, 4 cases.
Autumn, 39 and 21 cases. Winter, 23 cases.

We see that these cases occur most frequently in the autumn and especially in the month of October. They are generally accompanied by a hazy or smoky condition of the atmosphere, and this is the phenomenon which is generally known under the name of *Indian Summer.* It appears to be due to an uncommonly tranquil condition of the atmosphere extending entirely across the continent; and similar cases frequently occur in each month of the year from September to March, but are most common in October.

A comparison of all the facts which have been presented in this paper, together with my six former papers, appears to warrant the following generalizations.

1. Areas of low barometer result from a general movement of the atmosphere towards a central area, and this movement is accompanied by a deflection of the wind to the right, which causes a tendency to circulate around the center with a motion spirally inward.

2. This deflection to the right, which results from the earth's rotation, causes a diminished pressure within the area of this inward movement, and the pressure is still further diminished by the centrifugal force resulting from the circulation about a center.

3. The amount of the barometric depression depends upon the force of the wind, and the geographical extent of the revolving atmosphere. The effect of centrifugal force is not considerable except when the velocity of the wind approaches that of a hurricane. With a velocity of 100 miles per hour, the depression due to centrifugal force may amount to about two inches; but in the winter storms of the middle latitudes with a velocity not exceeding forty miles per hour, the depression due to centrifugal force seldom exceeds one or two-tenths of an inch. In these storms, three-quarters of the observed depression of the barometer is usually the effect of the earth's rotation; but in order that the depression at the center may amount to as much as one inch, it is generally necessary that this system of circulating winds should prevail over an area nearly 2,000 miles in diameter.

4. In North America, south of latitude 35°, areas of low pressure are less frequent and generally exhibit a less depression than near latitude 45°, because the area over which a cyclonic movement of the winds prevails is small; and this area is small because if a cyclonic area could be formed having a radius of 1,000 miles with its center in latitude 30°, its circumference must extend southward to latitude 16°, where the trade winds are steady and seldom interrupted. Such a diversion of the winds toward the north, even if it could be produced, could not be long maintained; so that a large cyclonic area with its center in latitude 30° is well nigh impossible; and it is impossible that there should be a great depression of the barometer in latitude 30°, except with a wind having a hurricane velocity. This is believed to be the reason why in North America the centers of great storms are generally found north of latitude 40°.

5. The causes which may produce a general movement of the atmosphere toward a central area are (A) unequal pressure as shown by the barometer; (B) unequal temperature; and (C) unequal amount of aqueous vapor. Of these three causes the effect of the first is generally so decided that the influence of the other two causes can only be detected by careful observation; but when the pressure of the air is nearly uniform over a large extent of country, the influence of the other two causes is sometimes very palpable, and their influence is generally seen in a slight deflection of the winds from the direction they would have if wholly controlled by the first cause. I have made a considerable collection of facts illustrating the influence of temperature upon the direction of the winds, which I intend to publish hereafter.

6. A cyclonic movement of a large mass of air is generally attended by an upward motion in certain localities, chiefly on the eastern side of the center of low pressure, and this upward movement results in rain-fall. The rain-fall is then not generally the original cause of the barometric depression, but rather an incident of the cycloidal movement of the atmosphere. The fall of the barometer during a rain storm cannot be ascribed to the simple condensation of the vapor of the atmosphere, as some have supposed, since a rain-fall of one or two inches prevailing over an area 300 miles in diameter near latitude 30° produces scarcely an appreciable effect upon the barometer. See tables on pages 2 and 3.

7. The progress of areas of low barometer in all latitudes is determined mainly by the same causes which determine the general system of circulation of the atmosphere; and their normal direction is changed by whatever causes may change the direction of the winds.

8. The heat which is liberated in the condensation of a large amount of aqueous vapor must exert an influence upon the movements of the air, so that while the rain is generally to be regarded not as the original cause but rather as one of the incidents of extensive cycloidal movement, if the rain-area has great geographical extent, it may have a decided influence upon the amount of the barometric depression and upon the velocity with which the storm advances; sometimes accelerating its motion, sometimes retarding it, and sometimes holding it nearly stationary in position for two or three days. In my former papers I have presented some facts which seem to authorize these statements, and I am collecting additional facts bearing upon the same question.

It may be thought that these generalizations present nothing original or novel, but several of them are disputed by meteorologists who have given no little attention to the subject.

In preparing the materials for this article I have been assisted by Mr. Edward S. Cowles, Ph.D., a graduate of Yale College of the class of 1873.

ART. II.—*The Germination of the genus* MEGARRHIZA, Torr.;
by ASA GRAY.

THE object of this brief communication is to describe a peculiar structure which *Megarrhiza Californica* exhibits in germination, and to call for observations upon other species, at the time of germination, in the hope of thereby extending our present imperfect knowledge of this genus of big-rooted *Cucurbitaceæ* of our Pacific coast. For the extraordinary peculiarity in question, being one which, in other cases, is known to exhibit itself in certain species of a genus (as in *Anemone* and *Delphinium*), and not in others, so it may in the present genus give aid in distinguishing the five species which have been characterized upon more or less incomplete or scanty materials.

The first species known was from Oregon; the specimens, being in flower only, were referred in Hooker's Flora Borealis Americana, i, 220, to *Sicyos angulatus*, but were separated in Torrey and Gray's Flora of North America, i, 542, under the name of *Sicyos Oreganus*. In the course of time it was found that there was a similar if not identical species in California, and apparently more than one, that they were perennial from very large and fleshy roots, that, while the flowers much resemble those of *Echinocystis*, the seeds were turgid, marginless, and with thick and fleshy cotyledons. Dr. Torrey, upon whom the examination of these plants devolved, many (about thirty) years ago proposed for them the generic name of *Megarrhiza;* but he refrained from publishing it, even omitted all mention of it in his account of Dr. Bigelow's excellent collection made in Whipple's Expedition (Pacif. R. Rep. iv, 1857), although good materials of that and other collections were in his hands, because he could not make up his mind whether he had to do with one variable species or with two or three. But in the sixth volume of the Pacif. Railroad Rep., which bears the same date of 1857, in Dr. Newberry's list of plants collected in Williamson's Expedition (p. 74), two species are enumerated, thus:

"*Megarrhiza Californica*, Torrey. Petaluma and Sonoma, California; April, in flower."

"*Megarrhiza Oregana*, Torrey. On the shores of Klamath Lake and banks of Willamette River, O. T.; August and September, in fruit."

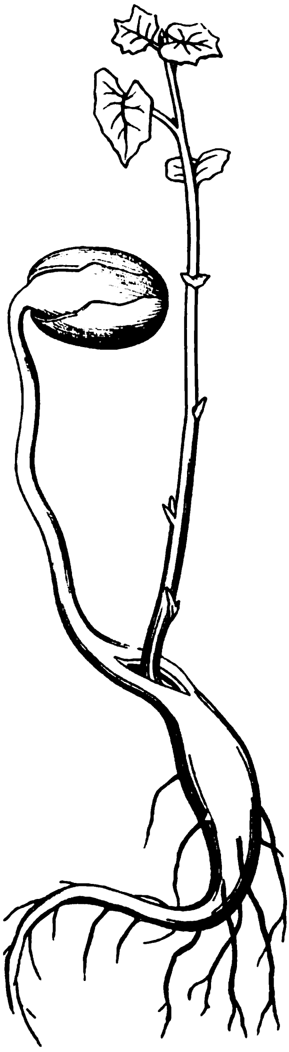
Before this, however, viz: in March, 1855, Dr. Kellogg, of San Francisco, communicated to the California Academy of Natural Sciences (Proc. Calif. Acad., i, 38), an account of one of these species, apparently the second, under the name of *Marah muricatus.*

A few years later, some plants having been raised in France from Californian seeds, M. Naudin (in Ann. Sci. Nat., ser. 4, xii, 154, t. 9, under date of 1859, but, as the letter-press shows, not printed until 1860 or 1861), published the plant which Dr. Torrey had called *M. Californica* under the name of *Echinocystis fabacea.* This extension of *Echinocystis* was adopted by Bentham and Hooker in their Genera Plantarum. It was, moreover, anticipated by Dr. Kellogg, who, in a second communication to the Californian Academy, under date of June 4, 1855, re-describes his former *Marah muricatus*, states that it "legitimately belongs to *Echinocystis*," and gives it the name of *E. muricatus.* When, shortly after Dr. Torrey's death, I superintended the printing of his account of the plants collected on our Pacific coast in Wilkes' Expedition, I found that he had left the article on this genus unwritten, and apparently had not determined either upon the number of the species or upon the distinctness of his proposed genus.

When in the recent preparation of the Botany of California the subject came to be studied anew by Mr. Watson, with the aid of more extensive materials, and when these materials were found to exhibit such diversities that at least five species had to be recognized (Bot. California, i, 240), with notable differences in ovary, fruit, seeds, etc., but no approximation to the eastern *Echinocystis*, it could hardly be doubted that Torrey's genus ought to be reinstated; and this was accordingly done.

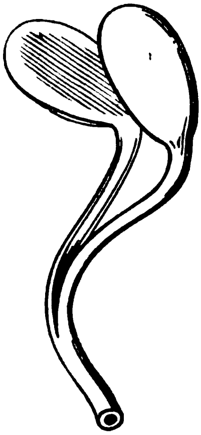
The *M. Californica* had been raised in the Botanic Garden of Harvard University many years ago, but I had not seen the germination; and we were never able to bring the plant into blossom, as it invariably died down to the ground soon after making a moderate growth. On germinating some fresh seeds early this spring, I was somewhat surprised to find that they came up in the manner of beans. Instead of remaining hypogæous, as from the great thickness of the cotyledons would have been expected, the body of the seed in its shell was raised well out of the soil upon what seemed to be a well developed radicle, like that of *Echinocystis*. If the cotyledons had expanded, though remaining fleshy, in the manner of *Phaseolus*, the difference between this and *Echinocystis*, with cotyledons truly foliaceous in germination, would be much less than had been supposed. I waited long to see if this would occur; I also waited in vain for the expected development of the plumule from between the bases of the fleshy cotyledons. After the lapse of about a fortnight, the plumule in all three of my germinating plantlets came separately out of the soil of the pot; and, on exposing the whole to view, the state of things represented in fig. 1 came to view. That is, the plumule came forth from the base of what appeared to be an elongated radicle (of two or three inches in length); and below this the thickening of the root, which acquires enormous dimensions in old plants, had already commenced. A large amount of the nourishing matter stored in the cotyledons had been carried down to the root and used in its growth as well as that of the plumule. The latter came from a cleft at the very base of the seeming radicle, which otherwise appeared to be solid. But on cutting it across toward the base this was found to be tubular, as shown at the bottom of fig. 2; and later, when more spent and beginning to wither, this stalk was separable from above downward into two, as shown in the upper part of the same figure.

1.



This, therefore, is a case in which long petioles to the cotyledons (of which there is no appearance in the seed), connate into one body, are developed and greatly lengthened in place of the radicle, which is thus simulated. It is the same as in *Delphinium nudicaule* of California, and some other species; only in that genus the cotyledons expand and become foliaceous. In the horse-chestnut petioles are also developed to the cotyledons to a moderate extent, but without union, (see Gray's First Lessons, fig. 24), thus pushing the radicle and plumule well out of the firm seed-coat, in which the very heavy and fleshy cotyledons remain; and the radicle itself, as in the pea, does not further lengthen. In *Ipomœa leptophylla* the radicle remains in like manner short, while petioles to the (here foliaceous) cotyledons develope to a great length, bringing these separately out of the ground, and the plumule between follows later.

2.



Botanists on the Pacific coast are earnestly requested to examine the germination of all the species of *Megarrhiza*, and to compare them with the figures and description here given. At least three species should be met with near San Francisco, and in neighboring parts of California. According to the characters assigned by Mr. Watson in the Botany of California, *M. Californica* should be known by its obovoid seeds, of less than an inch in length, with a small hilum at the narrow base: *M. Marah*, by its more numerous seeds horizontally imposed in a large fruit (of four inches in length), each seed roundish and depressed, flattened, an inch in diameter and about half as thick, with a prominent lateral hilum. *M. muricata*, by a nearly naked fruit only an inch in diameter, containing only two globose seeds of half an inch in diameter. *M. Oregana*, which is known to occur from the Columbia River to the north of California, appears to have seeds resembling those of *M. Marah*, but rather smaller; but they are not well known. The remaining one, *M. Guadalupensis*, of Guadalupe Island, off Lower California, is much out of ordinary reach, unless it should be found in the southern part of the State.

Mature fruits and seeds of all the species are much desired.

Fig. 1 represents a germinating plantlet of *Megarrhiza Californica*, of natural size, complete except the lower part of the root. Fig. 2 represents the cotyledons at a later period, with their united petioles separated from above, still united into a tube below, the lower end of which is cut away.

ART. III.—*On the absorption of Bases by the Soil;* by H. P. ARMSBY.

THE question of the nature of the absorptive power of the soil for bases may be regarded as still to a certain extent an open one. Although the researches of Henneberg & Stohmann, Peters, Weinhold and others have shown conclusively that the absorption is accompanied by a chemical reaction between the salt whose base is absorbed and the soil, an equivalent quantity of other bases being dissolved; and though the investigations of Way, Eichhorn, Rantenberg, Heiden, Knop and Mulder have as conclusively connected this reaction with the presence in the soil of certain zeolitic silicates which appear to be the agents of absorption; it has been the opinion of many distinguished authorities, e. g., Liebig, Brustlein, Henneberg & Stohmann, that the prime cause of absorption is physical in its nature.

The fact which more than any other has served to sustain this view is the peculiar effect of the concentration and volume of the solution upon the amount of absorption. As is well known a given weight of soil absorbs a greater amount of a base from a concentrated than from a dilute solution, and more from a large than a small bulk of the same solution, though the variation is in neither case proportional. This, it is considered, is proof that absorption is at least in part due to physical and not chemical force.

This force seems generally to have been assumed to be analogous to the surface-attraction exhibited by charcoal and other porous bodies. Peters and others hold that the physical force is the prime cause, and that the chemical phenomena are only secondary, while others believe that chemical action is the prime cause and is modified by physical force. Knop advances the theory (Bonitirung der Ackererde, pp. 39 and 152, Fres. Zeit., xiv, 246) that the soil has the power of *dissociating* salts in the presence of some substance like calcium carbonate which can unite with the acid, and that then the chemical union of the base follows.

Pillitz (Fres. Zeit., xiv, 55 and 282) has indeed found that, if a large volume of solution be filtered through a soil until no further absorption takes place, the absorption is proportional to the amount of soil, and that at a certain concentration of the solution the absorption reaches a maximum above which it cannot be raised. He concludes from this that the objections to the chemical view based on the variability of absorption are removed, since in his experiments the absorption was constant.

But these facts, however interesting and important, neither do away with the variability of absorption as ordinarily determined nor rob that variability of its force as an argument for the physical nature of absorption, since as Pillitz himself says even the most dilute solution is not exhausted, which must be the case were the variations due simply to a lack of sufficient material to saturate the soil.

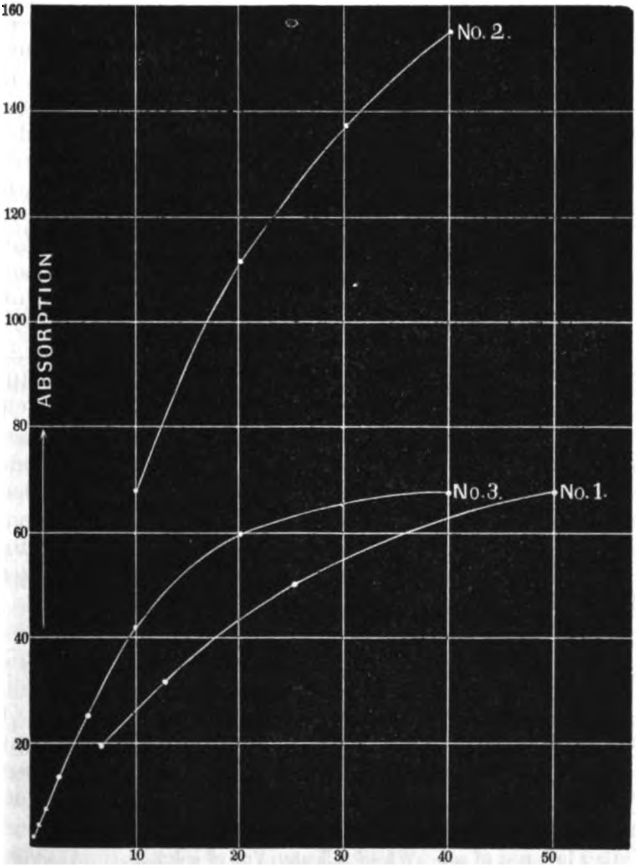
In view of the interest attaching to this question it seemed to me desirable to compare the behavior of the soil in this respect with that of pure hydrous silicates. If it should be found that the exchange of bases between these compounds and neutral salts showed the same variations as soil-absorption, then, whatever view might be held as to the cause of these variations, all possible objections to the theory which considers soil-absorption to be such an exchange of bases between the salt and the hydrous silicates known to exist in the soil would seem to be removed.

As illustrating the variations of soil-absorption the following determinations made in the laboratory of Prof. Knop in Leipzig may be adduced. Two soils were used: No. 1, Deposit of the Nile. No. 2, A loamy soil from the vicinity of Leipzig.

The absorptive power of these soils for ammonia was determined by Knop's method (Bonitirung der Ackererde, 49) by digesting the soil in the cold with a solution of NH_4Cl of known strength for forty-eight hours and determining the ammonia remaining in the fluid by means of the azotometer. The results denote the c. c. of nitrogen at 0° C. and 760 m.m. pressure contained in the ammonia absorbed, and the concentration of the solution employed is stated in the same way. It was found more convenient to vary the amount of the soil than of the solution.

				Absorption.	
	Nos.	N in 1 c. c. of Sol.	Wt. of Soil.	Soil No. 1.	Soil No. 2.
I.	1.	1·079 c. c.	50 grms.	67·7 c. c.	45·2 c. c.
	2.	....	25 "	49·6 "	28·4 "
	3.	....	12·5 "	31·5 "	16·2 "
	4.	....	6·25 "	18·4 "	9·3 "
II.	1.	2·158 "	50 "	111·9 "	67·3 "
	2.	....	25 "	77·7 "	38·2 "
	3.	....	12·5 "	52·2 "	20·3 "
	4.	....	6·25 "	33·1 "	12·7 "
III.	1.	3·237 "	50 "	137·8 "	
	2.	....	25 "	85·0 "	
	3.	....	12·5 "	48·8 "	
	4.	....	6·25 "	32·1 "	
IV.	1.	4·316 "	50 "	155·7 "	88·1 "
	2.	....	25 "	94·0 "	55·1 "
	3.	....	12·5 "	54·6 "	36·3 "
	4.	....	6·25 "	33·1 "	24·9 "

Representing graphically the results of the first series (I) we obtain the curve No. 1 in the figure, showing the influence of the relative volume of the solution on the absorption by soil No. 1. The other three series give exactly similar curves, and the influence of the concentration of the solution is seen in curve No. 2, which represents the absorption by fifty grams of soil No. 1 from solutions of increasing concentration.



But not only these experiments, but all others on the subject accessible to me show essentially the same result. With the exception of a single experiment by Laskowsky (Knop, Boni., etc., p. 150) the absorption never increases proportionally to the soil, nor is it, as is sometimes stated, independent of its amount.

In order to study the absorption of bases by hydrous silicates an artificial silicate was prepared in the method described by Way (Jour. Roy. Agr. Soc. of Eng., xi, 313).

Eighty grams of air dry aluminum hydrate were dissolved in a strong solution of soda (containing about 200 grams NaOH), the solution was diluted largely, and to it were added about 310 c. c. of commercial water-glass, containing 91 grms. SiO_2. A bulky, flocculent precipitate resulted which subsided readily and could be washed by decantation without much difficulty. The washing was continued till the washings showed no alkaline reaction, the precipitate collected on a filter and dried at 100° C. till it seemed dry to the touch. It was then pulverized, brought upon a filter, washed till the filtrate gave no precipitate with the solution of calcium chloride used in the experiments, and again partly dried at 100° C.

An analysis gave :—

Loss at 100° C	39·94
Dry substance	60·06
	100·00

The dry substance contains :—

SiO_2	48·42
Al_2O_3	23·16
Na_2O	14·20
H_2O	14·13
	99·91

A neutral solution of calcium chloride was also prepared by dissolving fused $CaCl_2$ in water, acidifying with HCl, and neutralizing with $CaCO_3$. 1 c. c. contained the equivalent of 0·01683 grams CaO.

Varying portions of the air-dry silicate were digested in closed flasks with the above solution diluted to five, ten, or twenty times its volume exactly as in the experiments with soil. The mixtures stood three days at ordinary temperature with frequent shaking, and then in 50 c. c. of the liquid the lime was precipitated as oxalate in the usual way, and weighed as oxide. The result calculated on the whole quantity of the solution and subtracted from the amount of lime originally present gave the absorption. The results in every case are expressed as CaO, as is also the strength of the solution employed. The following are the results.

Nos.	CaO in 1 c. c. of sol.	Wt. of silicate.	Vol. of solution.	Absorption.
V. 1.	0·003366 grms.	40 grms.	200 c. c.	*[0·6732 grms.]
2.	......	20 “	---	0·5952 “
3.	......	10 “	---	0·4172 “
4.	......	5 “	---	0·2432 “
5.	......	2·5 “	---	0·1324 “
6.	......	1·25 “	---	0·0680 “
7.	......	0·625 “	---	0·0328 “
8.	......	0·3125 “	---	0·0164 “

* Only traces of lime were left in the solution.

Nos.	CaO in 1 c. c. of sol.	Wt. of silicate.	Vol. of solution.	Absorption.
VI. 3.	0·001683 grms.	10 grms.	200 c. c.	0·2996 grms.
4.	......	5 "	...	0·2084 "
5.	......	2·5 "	...	0·1217 "
6.	......	1·25 "	...	0·0673 "
7.	......	0·625 "	...	0·0338 "
8.	......	0·3125 "	...	0·0198 "
VII. 5.	0·000841 grms.	2·5 grms.	200 c. c.	0·1151 grms.
6.	......	1·25 "	...	0·0663 "
7.	......	0·625 "	...	0·0359 "
8.	......	0·3125 "	...	0·0187 "

It will be seen that the same variations occur here as in soil-absorption. Representing the results of (V) graphically, and expressing the absorption in centigrams for convenience, we obtain the curve No. 3, similar in character to No. 1.

Further these results seem to correspond with those of Pillitz already mentioned. The existence of a "point of saturation" is simply due to the fact that there is a limit to the amount of replaceable bases in the soil. A similar limit seems to have been reached in some of these experiments. In experiment VII, 8, about two-thirds of the soda of the silicate has been replaced by lime, and an increase of concentration seems unable to carry the replacement further. The same is seen in VII, 7, and the corresponding ones of the other series, while in those experiments where this limit is not reached the absorption increases with the concentration in the same way as in soil-absorption. For the same reason, apparently, the absorption in the last four experiments of (V) and the last three of VI, decreases proportionally to the soil, seemingly unable to pass this limit of two-thirds. That the rest of the soda *cannot* be displaced is not probable, but it is evidently more difficultly replaceable. The high absorption of (VI, 8) is perhaps an error of experiment.

Since, now, it has been shown that the absorption of bases by hydrous silicates resembles in all essential particulars soil-absorption there would seem to be no reason why the latter should not be considered to be due chiefly to these silicates in the soil. That other agents may also be concerned to some extent, especially in the absorption of free bases, is doubtless true, but that any form of surface-attraction can decompose simple salts is yet to be proved.

In regard to the chemical or physical nature of absorption it will hardly be denied, in view of the results of Way, Eichhorn and Heiden, that the reaction between the hydrous silicates and a salt is essentially a *chemical* process consisting in a partial exchange of bases. The reason why the exchange is not complete would seem to be the same as the reason why, e. g., HCl and O when heated together are not completely converted into H_2O and Cl, or the reverse; or why, when two salts are mixed in solution, a partial decomposition takes place, as has been shown by Gladstone (Phil. Trans., 1855, p. 179) and others; viz: the so-called *action of mass*, or the tendency of the resulting new compounds to react on each other and re-produce the the original bodies. This tendency is specially marked when the total solubility of the system is nearly the same after and before the reaction, as where all the possible products are soluble or where one insoluble body gives rise to another.

The latter is exactly what occurs in soil-absorption, or the absorption of bases by pure silicates, and hence we may safely say that the variations caused by the volume and concentration are due to the influence of mass on a primarily chemical process.

This view has already been suggested by Ad. Mayer (Lehrbuch der Agricultur-chemie, ii, p. 93). It receives confirmation from the researches of Gladstone already alluded to. He added to a solution of ferric nitrate increasing portions of potassium sulpho-cyanate and found that each successive addition produced less and less ferric sulpho-cyanate, but that the ferric nitrate was never completely decomposed. His results represented graphically give a curve essentially like those for absorption already described.

According to this view it is the accumulation of sodium chloride in the solution which prevents the further absorption of lime by the silicate. If then sodium chloride were added to the solution in the first place, we should expect the absorption to be less. To test this (VII) was repeated with the addition of 0·1700 grms. NaCl (about equivalent to the $CaCl_2$ present) to each experiment. The following results were obtained.

Silicate.	Abs. without NaCl.	Abs. with NaCl.
2·5 grms.	0·1151 grms.	0·1039 grms.
1·25 "	0·0663 "	0·0595 "
0·625 "	0·0359 "	0·0303 "
0·3125 "	0·0187 "	0·0143 "

In every case the absorption has been decreased by the addition of the sodium chloride, as required by the theory.

We are then, I believe, justified in the following conclusions.

The absorption of combined bases by the soil consists in an exchange of bases between the salt and the hydrous silicates of the soil.

This exchange, which is primarily chemical, is only partial, its extent varying:

1st. With the concentration of the solution.

2d. With the ratio between the volume of the solution and the quantity of soil used.

The cause of these variations is probably the "action of mass," or the tendency of the resulting compounds to re-form the original bodies, the absorption actually found in any case marking the point where the two forces are in equilibrium.

Laboratory of Rutgers College, May, 1877.

ART. IV.—*Double-Star Discoveries with the* 18½-*inch Chicago Refractor;* by S. W. BURNHAM.

THE new double stars described below were discovered with the 18½-inch Clark refractor of the Dearborn Observatory, on the nights of October 1, 2, 4, 7, 10, 11, 15, 16, and 17, 1876, and are some of the results obtained in the use of that instrument during a period of three or four weeks, the only opportunity the writer has had of using it. The observations here given are not as complete as could be desired; some of the new pairs being only partially measured, and others not at all. A number of other new and interesting pairs were found, but the approximate readings of the circles, roughly noted at the time of finding them, are not sufficient to positively identify them in the star catalogues and thus fix their absolute places; and these with other suspected pairs, and new companions to prominent pairs and binary systems, are necessarily not included in the following list. The intention was to measure, during the course of the work, all new pairs on at least three different nights, in order to give, as accurately as possible, reliable micrometrical results with which future observations might be compared for determining the question of physical relation between members of the systems. This seemed to be the more important from the fact that many of these pairs are too difficult for ordinary apertures, and are practically beyond the reach of most of the well-known double-star observers in Europe; and a considerable time might elapse before the objects would be re-observed elsewhere. It is necessary to state, in explanation of its manifest incompleteness, that the work was unexpectedly, and without notice, terminated by the action of the officers of the Chicago Astronomical Society which has control of the instrument, and no opportunity has been afforded to complete the projected series of observations which was but just commenced. Enough is given, however, to show the value and effectiveness of the telescope in this important branch of astronomical research; and how much might be accomplished for science, if it were used for any other purpose than exhibition to visitors.

The reference numbers attached to these stars are the numbers in my double-star catalogues, seven of which lists, with the stars numbered consecutively, have appeared in the Monthly Notices of the Royal Astronomical Society, Astronomische Nachrichten, and in this Journal.

No. 437=L 4291.

$\left.\begin{array}{l}\text{R. A.}=2^{h}\ 12^{m}\ 26^{s}\\ \text{Decl.}=+3^{\circ}\ 39'\end{array}\right\}$

Not measured, but angle and distance estimated as follows:

P=45°± D=5″±

The principal star is about 7½ magnitude, and the companion not brighter than 11 of Struve's scale. The pair of small stars in the field, *sp* is Σ 247 *rej.*

No. 438=Σ 2538

R. A.=19ʰ 27ᵐ 3ˢ }
Decl.=+36°27′ }

A and B	P=43°·5	D=6″·32	(1876·8)
A and C	245·2	53·04	(1830·8)
C and D	52·5	6·07	(1830·8)

The three large stars, A, C and D, constitute the double star Σ 2538(=S 719), but the small companion near the principal star is now recorded for the first time, and is probably too minute for ordinary telescopes. The measures given above of C and D are by Struve. These stars seem, by a comparison of Struve's results with those obtained later by Mädler, Secchi and Otto Struve, to be relatively fixed, but some of the measures are not very accordant. By a single observation I found these angles respectively, 237°·1 and 51°·9, but there may be an error of 10° in reading micrometer of the first. There is still another new member of this group, in an exceedingly faint star almost exactly midway between A and C. No opportunity occurred to measure this. Struve gives the magnitudes of A, C and D as 8·2, 8·3 and 8·7 respectively.

No. 439=Arg. (29°) 3845

R. A.=19ʰ 55ᵐ 56ˢ }
Decl.=+29° 30′ }

The principal star is about the eighth magnitude (Argelander, 8·1), with a small companion. The measures of one night give:

P=249°·7 D=2″·70 (1876·8)

No. 440=L 38520

R. A=20ʰ 1ᵐ 27ˢ }
Decl.=+35° 27′ }

A and B	P=61°·3	D=6″·47	Mags. 7·0 . . 12+	(1876·8)
A and C	25·8	7·75	11·0	(1876·7)
A and D	296·0	11·27	9·5	(1783·7)
A and E	106·8	28·15	11·5	(1876·7)
A and F	32·8	29·45	7·5	(1783·7)
F and G	113·0	10·12	12·	(1876·8)

The large stars (A, D, F), of this interesting group have long been known, and constitute the double star ♅ III. 113 (=Sh 314=Σ 2630 *rej*). The small attendants, C and E, I found with the 6-in. refractor in 1875. The faint star, G, was discovered by Mr. I. M. Ward of Belfast, widely known for his remarkable acuteness of vision, with an aperture of only 4·2-in. The very minute companion, B, was added with the 18½-in., the whole forming one of the finest multiple systems known. Of the measures given above, D and F are by Sir William Herschel; C and E by Baron Dembowski; and B and G my own results on the occasion last referred to. The relative situation of the stars known to the early observers appears to be substantially unchanged. For A and D Dembowski finds:

P=300°·7 D=11″·12 (1876·7)

By comparing the measures of Sir John Herschel and Sir James South, with the recent observations of Baron Dembowski, there seems to be an error in Herschel's distance of A F;—

P=28·2 D=36″·52 (1823·6)
28·2 35·98 (1876·7)

The relation of the closer stars can be determined only after a series of carefully repeated measures, but it is at least probable that they will be found to have some physical connection.

No. 441=L 39013

R. A.=$20^{h}\ 12^{m}\ 37^{s}$
Decl.=+28° 46′

This is a 7·5 m. star with very small satellite, measured on one night as follows:

P=65·°4 D=5″·87 (1876·8)

No. 442=Weisse xx. 456

R. A.=$20^{h}\ 13^{m}\ 3^{s}$
Decl.=+37° 11′

A fine group consisting of three large stars, each about 8·5 m. with closer minute companions. The following measures were made on this occasion:

A and B	P=104°·1	D=18″·47
A and a	157·5	4·40
A and b	157·±	7·±
A and c	332·5	19·55
B and d	164·3	8·12
B and C	48·6	17·69

There are several other small stars near not measured.

No. 443=L 39293

R. A.=$20^{h}\ 19^{m}\ 12^{s}$
Decl.=+28° 37′

Angle and distance estimated only:

P=120°± D=10″± Mags. 7·5 . . . 11·5

There is a third star following, about 30″ distant.

No. 445=Cygni 287

R. A.=20^h 58^m 23^s
Decl.=+28° 37′

Very unequal pair; the principal star 7 m. in Lalande.

P=90°± D=4′±.

This is L 40821.

No. 446=Weisse xxi. 344

R. A.=21^h 15^m 44^s
Decl.=+32° 56′

A pair of small stars, the larger 9 m. near and south following a bright star.

P=261°·7 D=2″·30

No. 447=Vulpeculae 129.

R. A.=21^h 18^m 45^s
Decl.=+24° 48′

This is a bright star, about 6 m. with a difficult companion in the direction of 340°. Distance not noted, but probably under 5″. No opportunity was afforded to measure or examine it a second time.

No. 448=L 41874

R. A.=21^h 24^m 35^s
Decl.=+44° 24′

There is some uncertainty about the place of this pair. It is assumed to be the above 7 m. star in Lalande, which is nearly in the observed place, but may be a larger star south following. Estimated as follows:

D=2″± Mags. 7·0 . . . 11·0.

A distant companion preceding.

No. 449=Radcliffe 5335.

R. A.=21^h 34^m 42^s
Decl.=+41° 11′

The three larger stars, A, C and E, were discovered by Sir William Herschel (=H III. 110), and also entered in the Pulkowa catalogue (=$O\Sigma$ 447). The new members of the system, B and D, are very minute, and might be easily overlooked with even a large aperture. My measures of these, and Dembowski's of C and E are as follows:

A and B	P=19°·1	D=6″·78	(1876·8)
A and C	170·5	13·71	(1866·6)
A and D	248·2	17·94	(1876·8)
A and E	45·7	29·13	(1866·6)

Dembowski gives the magnitudes of A, C and E as 7·0, 10·8 and 7·7 respectively. A comparison of the measures of these stars with the early observations of Herschel, would seem to indicate considerable change, but this is not confirmed by the intermediate measures of Otto Struve.

Herschel	A and C	P=157°·6	D=13″·90	(1783·8)
O. Struve	A and C	169·4	13·86	(1848·3)
Herschel	A and E	49·4	25·97	(1783·8)
O. Struve	A and E	45·3	29·00	(1848·3)

The close agreement between the measures of O. Struve and Dembowski accords with my own results on the occasion of observing the new companions, when the angles came out 170°·5, and 44°·9, respectively.

No. 450=B. A. C. 7931

R. A.=22^h 38^m 40^s
Decl.=+38° 50′

As a double, this beautiful object is found in the catalogues of both Struves, and Herschel (=Σ 2942=*O*Σ 478=*H* 1802). Struve's magnitudes are 7·0 and 9·2. The colors are very striking, the larger being, according to Struve, reddish gold, and the smaller, ash-color. A third much smaller star was discovered with the 18½ in., and measured once as below:

A and B	P=282°·4	D=2″·66	(1831·6)
A and C	232·0	10·23	(1876·8)

Measures of A and B by Struve. Dembowski gives, P=280°·6: D=2″·80 (1866·6), from which it is safe to infer there is no substantial change in the relation of these stars, and this view is supported by the measures of Otto Struve, Mädler, Dawes, and others. The small star is not a difficult object with the 18½ in., and can perhaps be measured with a smaller aperture.

No. 451=15 Lacertae.

R. A.=22^h 46^m 37^s
Decl.=+42° 40′

This star was seen with a minute attendant, roughly estimated from memory as about 20″ distant. The angle was not noted, and no opportunity occurred to re-examine and measure subsequently.

No. 452=L 44915

R. A.=22^h 51^m 37^s
Decl.=+42° 22′

A fine pair observed about the same time as the preceding, and like that only estimated for the purpose of certain identification:

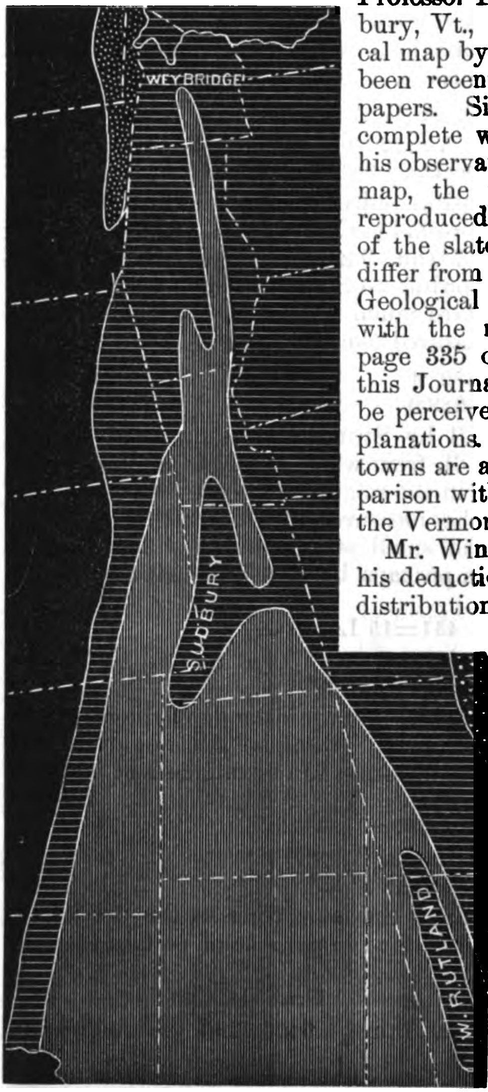
P=270°± D=6″±

The large star is 6½ or 7 magnitude, and the companion below 12 of Struve's scale.

Chicago, May 5, 1877.

ART. V.—*Supplement to the Account of the Discoveries in Vermont Geology of the Rev. Augustus Wing*; by JAMES D. DANA.

26.



SINCE the publication of the preceding number of this Journal, containing the concluding part of the account of Mr. Wing's discoveries, I have received from Professor H. M. Seely, of Middlebury, Vt., a manuscript geological map by Mr. Wing, which had been recently found among his papers. Since the account is not complete without the results of his observations contained in this map, the portion of it is here reproduced in which his outlines of the slate and limestone areas differ from those of the Vermont Geological Map. By comparing with the map and remarks on page 335 of the last volume of this Journal, the differences will be perceived without special explanations. The outlines of the towns are added to aid the comparison with the colored map in the Vermont Report.

Mr. Wing's map contains also his deductions with regard to the distribution of the formations—part of which are not yet established. The West Rutland and Sudbury areas are both made Chazy along the center and Trenton along the east and west borders, which may be true, although only Chazy fossils have been distinguished in the former, and Trenton in the latter. Along either side of the central slate belt, which is Hudson River (Cincinnati) in age, a belt of color indicating Trenton extends; then others, more remote, for Chazy, Calciferous and Potsdam: and the Chazy east of the slate-belt extends two-thirds of the way to the quartzyte. These points in the map rest mainly on fossils, except the eastern boundary of the Chazy, and the periods assigned to the part of the limestone still farther east.

ART. VI.—*On the relations of the Geology of Vermont to that of Berkshire*; by JAMES D. DANA.

IN my memoir on the Quartzyte, Limestone, and associated rocks of Great Barrington, Berkshire Co., Massachusetts, published in this Journal in 1872 and 1873,* I based the conclusion there presented with regard to the age of the Berkshire rocks largely on the single discovery of Mr. A. Wing, of Chazy fossils in the West Rutland limestone, the only one of his that had then been made public. The wider knowledge of his discoveries which we now have, through his notes and letters, gives a better basis for a decision, and I propose to consider the bearing of the facts as now understood.

We have first to enquire what reasons there are for making the geology of Vermont a key to that of Berkshire. These are afforded both by the geographical and the stratigraphical arrangement of the rocks. The facts given beyond are in part contained in my former memoir. Others are added from my more recent observations.

1. THE GEOGRAPHICAL ARRANGEMENT OF THE ROCKS.

Whatever be true of the whole Green Mountain region, the *western half* of it, including the "Eolian limestone" and its associated rocks, is eminently a natural area, both as regards its topography and its rocks. This north-and-south area is divided among four States—three of Western New England, and the State of New York. But the boundaries of Vermont, the northern of the series, are of political authority, not geological; and so are those of Massachusetts, Connecticut, and New York.

(1.) *The Limestone formation.*—The great limestone belt of Vermont stretches southward, without interruption or diminished width, into Berkshire Co., Massachusetts; through Berkshire, into Western Connecticut; and, continuing its south-by-west trend over Canaan and Salisbury, it passes out of Connecticut, still as wide as in any more northern part, into eastern New York, over the towns of Amenia and Dover, to Pawling. Thence it still stretches southward for seven or eight miles, but with narrowing limits, and finally ends in a narrow strip among the flexures of hard gneiss rocks. It is one of the long Green Mountain formations.

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* Vol. iv, 362, 450, (504); v, 47, 84; vi, 257.

(2.) *The Quartzyte series.*—Associated with the limestone belt, and following mainly its eastern border, there is a *quartzyte* series, consisting in Vermont of quartzyte and crystalline slate or schist (hydromica slate, sometimes chlorite slate), and rising at intervals into mountain ridges. This quartzyte formation commences just abreast of the northern limit of the "Eolian limestone" in Vermont; and it follows it southward through Massachusetts, and into Connecticut, being, throughout, its close attendant.

(3.) *The Slate or Schist series.*—Again, along and west of the central portion of the limestone region, and on much of its western border, there are ranges of hydromica slate often chloritic, with some clay-slate. A broad slate belt is a prominent feature of the region in Vermont west of its center. It commences within ten miles of the northern terminus of the limestone, extends south with increasing width and height, rising at intervals into mountain elevations 2,500 feet or more in height, Herrick Mountains, in Ira, having a height of 2,661 feet, and Equinox Mountain, in Manchester, 3,872 feet (Guyot) above tide-level. It continues with unchanged course into Massachusetts, or rather along the connecting borders of Massachusetts and New York, and this part, south of Vermont, has long borne the name of the Taconic Mountains; and here it rises into peaks nearly as high as those of Vermont, Graylock being 3,600 feet in height, and Mount Everett, 2,634 feet. Further, the Taconic Mountains consist chiefly of hydromica slate more or less chloritic, like the southern portion of the same range in Vermont.

Thus there is a marked unity in the area from north to south indicated not merely in the continuity of the limestone formation, but also in the like continuity of the whole series of associated rocks—limestones, quartzyte and schists—of the eastern, middle and western portions of the great north-and-south area. And this unity favors strongly the idea of oneness in age, in origin, and in mountain-making movements.

The lithological identity is not perfect throughout; yet the differences are introduced by very gradual transitions, evident only as the whole area from north to south is surveyed, and hence they are additional proof of the unity. They are differences mainly in *grade of metamorphism.*

The great central slate-belt of Vermont commences to the north, according to the Vermont Report, in a *clay-slate* belt. Thirty miles or so south, hydromica slate, a more crystalline rock, commences on the two borders of the clay-slate area, with the band of the eastern border much the broader—corresponding in this with the general fact of a higher degree of metamorphism on the east. Seventy miles farther south, in the Taconic Mountains, and its eastern spur, Graylock, the hydromica slate is in part of somewhat coarser texture and more chloritic, and this same rock constitutes Mount Washington in southwestern Massachusetts, near the southern termination of the Taconic range. It even becomes in part mica slate.

The distance from the north extremity of the slate belt to Mount Washington, through which this small change occurs, is 150 miles.

The ridges in Berkshire south of Graylock, or over the western third of the limestone region, including the ridges either side of West Stockbridge village, and the Tom Ball ridge farther south, west of Williamsville, consist of the same rocks as Graylock, with scarcely appreciable difference. Some of the beds are garnetiferous.

The ridges along a line a little farther east, near the center of the limestone belt, that is, those next east of Tom Ball, and east and west of Great Barrington, have the hydromica slate replaced by mica schist, and then by mica schist and gneiss, part of it a thick-bedded granitoid gneiss. South of Great Barrington, in Sheffield, the schist of ridges in the midst of the limestone area (which has here great width) is a coarse mica schist containing abundantly garnets and crystals of staurolite; and the same staurolitic mica schist exists under similar circumstances near Falls Village, in Canaan, Connecticut, the next town south of Sheffield, and also, farther south and west, in Salisbury. Thirty miles south-by-west of Canaan, about Pawling, and beyond to the termination of the limestone belt, the associated rock is mica schist or gneiss.

The schists, according to the above facts, become more and more crystalline on passing southward—chloritic hydromica slates giving way to mica schist, garnetiferous and staurolitic mica schist, and gneiss; but only by very gradual transitions. It should be here kept in view that the difference in constitution between hydromica slate and mica schist consists simply in the presence of a few per cent (three to six) of water in the mica of the former, and only one or two or none in that of the latter; and that gneiss has merely the distinction of more feldspar and less mica than mica schist.

A parallel change takes place in the associated limestone formation. To the north, in central Vermont, and especially along the western portion of the limestone region, occur the areas of grayish half-altered or semi-metamorphic limestone, affording distinguishable fossils. Further, the limestone of this northern portion of the Eolian limestone is generally very fine in grain even where of the purest white color. In Pittsford and Brandon are found the best of statuary marbles, looking like the finest loaf-sugar in texture. South of Pittsford, in Rutland, the marble is a little less fine in its grain than it is farther north; in Berkshire, it is mostly much coarser, none answering to statuary marble existing anywhere; and in southern Berkshire and Canaan, Ct., it is still coarser in crystallization, and abounds also in many places in tremolite, white pyroxene, and mica. Thus the fact of intenser metamorphism to the southward is as plainly apparent in the limestones as in the schists.

After this survey of the facts we have to admit that the differences are so distributed geographically as to prove unity of area and rocks, rather than diversity.

Similar differences, depending on degree of crystallization, are found in going *from west to east* in Massachusetts, as in Vermont. The rock of the Taconic Mountains is mainly hydromica slate and chloritic hydromica slate; and of ridges, *farther west*, in Columbia County, New York,—as in Copake at the foot of the mountains,—a finer hydromica slate and clay-slate, with bluish semi-crystalline limestone. But going eastward, in Berkshire, to Stockbridge and Great Barrington, and farther east to Monterey and Tyringham, there are, as illustrated in the facts stated beyond, first a coarser hydromica slate, partly garnetiferous; then fine-grained mica schist and gneiss; and then coarser and harder varieties of the latter rocks; and the crystalline limestone, which is almost free from foreign crystallizations in Stockbridge and West Stockbridge, contains large crystallizations of white pyroxene or tremolite in some places in Lee, Monterey and Tyringham.

2. The Stratigraphical Relations.

In Vermont we have found the following cases of *conformable superposition or interstratification*, as described in the account of Mr. Wing's researches, and illustrated in the figures of sections accompanying.

(1.) The limestone and schists conformable.

(2.) The quartzyte and schists conformable.

(3.) The quartzyte and limestone, and also the quartzyte, schists and limestone, conformable.

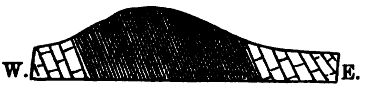
The *first* of these Vermont cases of conformability is illustrated in the sections on pages 338, 340, 344, 346, 347 of the last volume of this Journal; the *second*, in the constitution of the quartzyte formation, as explained on page 411; the *third*, in the sections presented on pages 340 and 412.

The following facts show that wholly similar cases of conformable superposition exist in Berkshire.

(1) *Interstratified limestone and schists.*[*]

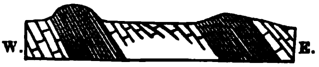
Fig. 1 represents a very common case of this first kind. Chloritic hydromica slate, dipping eastward, lies between strata of limestone which have the same dip. Examples occur in the southern third of the ridge called Tom Ball, southwest of Van Deusenville; also in Alvord, west of Tom Ball; in West Stockbridge; along much of the Taconic range, the slates having eastward dip between limestone strata of like dip; and in many other places. Two miles east of Tom Ball, in Glendale, the structure is repeated with thin strata of the schist as in fig. 2; moreover, the schist, is here a coarse *mica schist* instead of hydromica slate. West of the village of Great Barrington, there is a ridge of schist between limestone, as in fig. 1, but the schist is mica schist with some gneiss, and a thin bed of quartzyte. A few miles farther south, in Sheffield, in the midst of the limestone area, and not far from its center, the conditions in fig. 1 exist, but with the schist a mica schist containing staurolites and garnets.

1.



South end of Tom Ball.

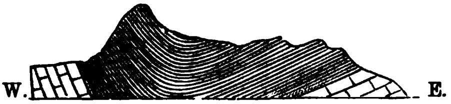
2.



West of Glendale.

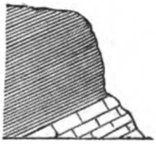
Examples also occur in which the dip is comparatively small. At the north end of Tom Ball the position of the rocks is as represented in fig. 3, in which on the east the limestone dips west 18° to 20° under the chloritic hydromica slate, containing in some places many garnets, and passing also into mica slate. The schist overlies the limestone in a synclinal.

3.



North end of Tom Ball.

4.



West of Glendale.

East of the north end of Tom Ball, on the road to Glendale, the limestone dips eastward 25° under a bluff of garnetiferous mica schist (fig. 4).

The facts connected with Graylock, in Northwestern Massachusetts, the highest of the Taconic peaks, point to a synclinal (or a synclinal with subordinate anticlinals and synclinals), much like that of the north end of Tom Ball, as shown in figure 5, by Emmons, here repeated.* The same structure exists in Mount Washington in Southwestern Massachusetts, the next highest summit of the range. At the *eastern* foot of this mountain the limestone dips *westward* at a small angle, (25° to 30°), beneath the chloritic hydromica slate, as I have described in a former article;† and the more eastern and highest peak of the mountain, called Mt. Everett, partakes of this westward dip; while in Copake, at the *western* foot, where the dip of the slate is eastward, the limestone dips *eastward* conformably to the slate, (the strike N. 20°–25° E., dip 40°–50°). In my examinations in Copake I had the guidance of Mr. William Miles, who had thoroughly explored the limestone localities. Besides the many conformable outcrops over the interior of the valley, there were others of large extent close to the slate of the mountains, and one where the limestone and slate were seen in contact.

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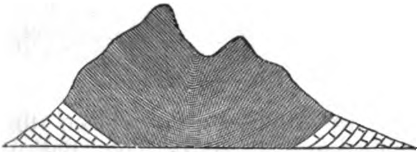
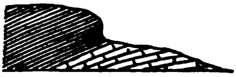
[*] In all the figures the blocked areas represent limestone; the simply lined, slate or schist; the lined and dotted, quartzyte. Moreover, the right end is the *eastward* end.

5.

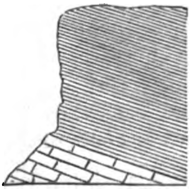

Graylock.

6.

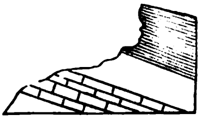

Half mile N. of Housatonic, west of the Old Furnace.

Again, half a mile north of Housatonic, west of the river, the section in fig. 6 is seen in an abandoned quarry. The limestone dips 10° to 25°, and passes beneath mica slate. In Canaan Mountain, Connecticut, in the southwest front there are 150 feet of limestone at base, dipping 15° to 20° to the eastward underneath mica schist (fig. 7). In the same town, at Falls Village, west of the Housatonic River, a ridge (fig. 8) consists of limestone below dipping at an angle of 15°–20° under a mica schist containing garnets and staurolites. The mica schist forms the upper part of the hill and the limestone outcrops toward its base.

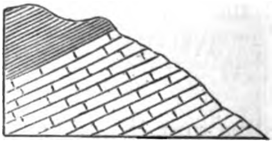
7.


Canaan Mountain. Southwest Front.

8.


Falls Village, Canaan. West side of river.

9.


Hill west of the village of Tyringham.

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* See last volume of this Journal, p. 347. † This Journal, III, vi, 266, 1873.

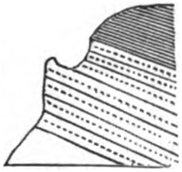
Further, in the most eastern of the limestone areas, in Tyringham, twelve miles east of the Taconic range, a hill, just west of the village, having a height of 450 feet above the bridge near its base, consists of well stratified limestone to within sixty-five feet of the top, (fig. 9); and above this of mica schist (the contact distinct), and very hard whitish thick-bedded gneiss; the whole dipping southeast 20° to 28°, with the strike N. 40°–45° W. Within the limestone stratum, fifty feet below its upper limit, there is a thin layer of mica schist.

These examples are sufficient to illustrate the point in view. Two others are given beyond.

(2.) *Interstratified quartzyte and schists.*

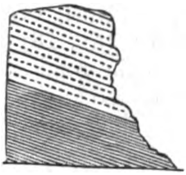
At the east front of Monument Mountain, half way from Stockbridge to Great Barrington, quartzyte overlies mica schist and gneiss (fig. 10), the dip 15° to 25°, to the southeast. The quartzyte is a hard kind without bedding, but vertically jointed. At the western end of the same mountain, opposite the village of Housatonic, the quartzyte, which forms the bold part of the front and rises to its greatest height a little back from the front, is at last capped by mica schist and gneiss (fig. 11), a continuation of the stratum that *underlies* the quartzyte of the eastern front. The quartzyte is here mostly devoid of bedding; but in its upper part, the bedding is distinct and parallel with that of the schist. This stratum of schist is locally a handsome granitoid gneiss half a mile to the eastward, at the top of the western half of Monument Mountain, showing in hand specimens no bedding whatever; but in most parts of the mountain it is rather mica schist than gneiss.*

11.



West end of Monument Mountain.

10.



East front of Monument Mountain.

East Mountain, rising from the Great Barrington Valley half a mile east of the village, consists below of thick-bedded gneiss, similar to part of that of Monument Mountain, but contorted in its bedding and dipping 40° to 50° to the eastward; at top, for the upper 100 feet, it is laminated quartzyte (fig. 12), resembling the laminated quartzyte of many other localities in the limestone region. This quartzyte is gneissoid in many places, or a sandy gneiss, making manifest thereby the close relations of the two rocks.

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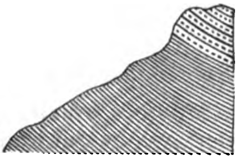
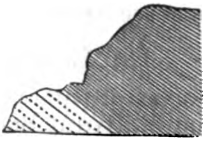
* This section of the western end of Monument Mountain is not here continued to its base, because the observations of this part were not wholly satisfactory owing to the concealment of the rocks by the soil. The stratum of schist in my former published section was inferred to exist there below the quartzyte, as I state in describing the section, from the great number of blocks over the surface; and that of the underlying limestone from small exposures along a path up the lower slopes of the mountains south of the old furnace, and from some very large masses of limestone on the east bank of the river, above the furnace, which may possibly be transported blocks.

12.



East Mountain, Great Barrington.

13.



Cobble Hill, South Canaan.

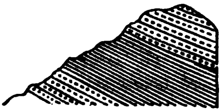
In South Canaan, east of the village, Cobble Hill consists below, to the west, of a soft-bedded quartzyte, dipping southeastward 40° (fig. 13), twenty to twenty-five feet of which are exposed on the road side; next above, a stratum of mica schist and thin-bedded gneiss, containing scales of both black and white mica; and then a whitish, granite-like gneiss. The quartzyte contains at intervals, in its upper part, streaks of black and white mica, and thus exhibits its relations to and passage into the overlying gneiss.

East of the village of Lee, a low ridge consists below of quartzyte; at middle of mica schist; and at top of quartzyte—all dipping eastward 15° to 25° (fig. 14).

(3.) *Interstratified quartzyte, limestone, and schists.*

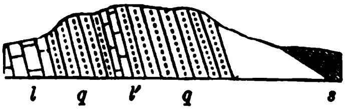
The fact that the quartzyte keeps by the side of the limestone, with small exceptions, from its northern limit southward to Connecticut suggests that there is a close stratigraphical connection between them. Further, seeing that the limestone occurs interstratified with the schists, and also the quartzyte of the same region with the same schists, there would seem to be hardly any ground for questioning the inference that the quartzyte and limestone are parts of the same great series of formations. On these grounds and the occurrence of limestone near by, it would be a reasonable inference that the strata of

14.



East of the village of Lee.

15.

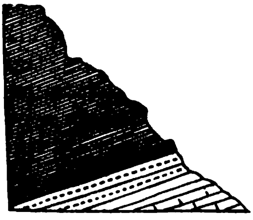


Quartzyte ridge east of south end of Tom Ball.

fig. 14 and the limestone are conformable. But there is also demonstrative evidence of this relation in sections. Fig. 15 represents a section of a ridge east of the southern part of Tom Ball. Limestone, dipping eastward 70° to 80°, adjoins a hard quartzyte; and in the quartzyte there is a stratum of impure limestone (*l'*) dipping with the other limestone.* This stratum indicates the dip of the quartzyte, which is elsewhere without bedding, and shows the conformability of the two rocks. East of the ridge there is an outcrop of mica schist, thirty rods east of the eastern outcrop of quartzyte, having nearly the same strike though less dip; so that we have all three rocks associated in the same section.

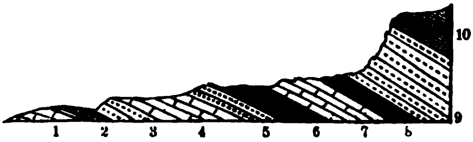
Fig. 17 represents several alternations of quartzyte, schist, and limestone, near Devany's quarry, four miles east of Great Barrington, all with small eastward dip; and here also mica schist and gneiss alternate with the other rocks, and, besides, constitute the upper stratum at the quarry. At this place, the intervals of earthy surface between the outcrops are as follows: between 3 and 4, fifty yards; between 4 and 5 (limestone and overlying quartzyte), hardly a yard; between 5 and 6, a marshy spot of forty yards; between 6 and 7, fifty yards; 7 and 8 (limestone and overlying gneiss) are in contact, and so also are 9 and 10 (quartzyte and overlying gneiss). No. 1 is the eastern border of the limestone of the Konkaput valley. The thinner lower layers of quartzyte in this section have little lateral extent. Devany's bluff is part of the southwestern foot of Beartown Mountain. The schist at the top of the bluff, (10, fig. 17), continues upward to a height of 800 or 900 feet above the upper quartzyte, being the rock of the mountain; and at this southern extremity of the mountain it has a small dip (10° to 25°) to the northeastward, so that the quartzyte and limestone of the Devany region is overlaid by at least 800 feet of schist. This schist is mostly a whitish and gray gneiss, very tough and hard; but with it there is granulyte, gray and black mica schist, and blackish hornblendic schist.

16.



Three-mile Ridge, west side of Konkaput Valley.

17.



Devany's Quarry, east side of Konkaput Valley.

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* This Journal, III, v, 84.

Fig. 16 exhibits the stratification in Three-mile Ridge,—a ridge on the opposite side of Konkaput valley from Devany's bluff, and shows the same succession essentially as on the Devany side—namely, limestone (that of the Konkaput valley) below; next quartzyte; next a great thickness of gneiss—not less than 800 feet. Three-mile Ridge extends southward (S.S.E.), with rather an abrupt front, and shows in a distant view nearly horizontal lines of stratification. The dip is mostly 25° to the northwest; but at base, toward the notch passed through by the road to Great Barrington, it is diminished to 8°. The gneiss (as may be seen three or four hundred yards south of the notch) rests on a stratum of quartzyte. It is hard quartzyte, but has the bedding distinct. It includes, besides some interrupted micaceous lines, a layer a foot thick of gneiss; but this gneiss layer, after a few rods, fades out to the northward and becomes a layer of quartzyte scarcely distinguishable from the rest of the quartzyte. Thus again, the distinction between quartzyte and gneiss in Berkshire proves to be of no more importance than that of quartzyte and hydromica slate in the quartzyte formation of Vermont. The soil conceals at this place the lower part of the quartzyte stratum, and the underlying rock or rocks; but, half a mile southeastward, along a road which runs nearly parallel with the mountain and not far from its base, and also between this road and the mountain, the limestone of the Konkaput valley outcrops with a small northwestward dip (15°–20°), conformable to the schist of the mountain; and these outcrops continue numerous for more than a mile. In one knoll, toward the mountain, the beds were found to dip eastward, but this was an exceptional case. Elsewhere the dip was northwestward, and at one spot the limestone was seen directly overlaid conformably by the schist.

I have above given the facts of my own observation. The same general conclusion with regard to the interstratification of these formations was long ago reached by Professor Edward Hitchcock, and announced in his Report on the Geology of Massachusetts. Speaking of the quartzyte, he says (Report of 1841, p. 590): "it alternates with and passes imperceptibly into gneiss and mica slate; and in fact it might very properly be regarded as a member of the gneiss and mica slate formations;" in Berkshire "it is frequently interstratified with gneiss and mica slate, especially along the eastern side of the valleys, as in Tyringham, Great Barrington and Sheffield."

He also states (p. 573 and beyond) that in Berkshire, the limestone occurs interstratified with the gneiss, mica slate, talcose slate and quartz rock of the region; that in New Malborough and Tyringham it is found in beds between the strata of gneiss, as at Hadsell's lime quarry; and that its interstratification with mica slate may be seen in numerous places in all parts of the county. He adds that he had not "met with a spot where the limestone is in direct contact with quartz rock; but as this rock frequently alternates with gneiss and mica slate, and the latter with the limestone, they must all be regarded as interstratified with one another."

Before Professor Hitchcock's observations were made, Professor Dewey announced in this Journal, in 1819, that the Berkshire limestone at the *Cave* or *Falls* in Adams, east of Williamstown, and also west of the Hoosac, *rests on mica slate.* Further, Professor Silliman, in the second volume, 1821, gives an account of the interstratification of the limestone and mica slate in Salisbury, Ct., west of the Housatonic, saying that "in the course of five or six miles there are as many alternations and successions of these two rocks," and "their junction in some places is exactly defined."

Abrupt transitions in dip or strike occur in some places which suggest that there is unconformability. But the above-explained actual sections prove them to be exceptional; and this is sustained by other facts. They are common over the broad areas of crystalline limestone moderate in dip, and of rare occurrence over the regions of schist, and also in the limestone areas close adjoining the schist. When making my first section of Western Connecticut, I passed from the schists, which had given regular dips and strikes, to the wide limestone area of Canaan; and expected to find in it essentially the system and regularity of position met with in the other rocks. But the observations of dip and strike were soon found to be of little value except as regards questions of local interest; they could not be used to determine either the direction of the uplifting force, or that of conformability in the formations, because of the abrupt local changes, which sometimes amounted to 50 or 60 degrees in dip and strike in a few rods. The same irregularities occur over all the other limestone areas of the Green Mountain region except where the beds dip at a high angle. Examples occur in the broad valley east of Monument Mountain, at a quarry half a mile distant from the bold front of the mountain, where the beds are vertical; in the valley west of Devany's quarry, just west of the place where the section represented in fig. 14 was obtained; in the Housatonic Valley between Housatonic village and the old furnace; in the vicinity of Glendale and Stockbridge; in the valley of West Stockbridge, and in other places. In sections observed close by the intervening ridges of schist, the irregularities are with a rare exception absent and the conformability to the schist is placed beyond doubt.

An unconformable limestone ledge is alluded to above as existing in the valley near the Devany bluff. The *conformable* limestone-outcrops extend along the side of the valley for a fourth of a mile. But toward the west end of the series, in front of the conformable outcrops, that is, a little nearer the middle of the valley, there is a ledge with a dip of 80° to 85°, instead of 25° or 30°. Its little extent shows that it is one of the local exceptions. And this is made more manifest, and its existence partly explained, by the fact that in the same transverse line across the flat valley, and just beyond its middle, there is a hill of schist whose beds dip 50° to the westward, instead of the usual 25° or less. The schist in the mountains forming the sides of the valley has little variation in dip for several miles.

The reason for these irregularities is to be found in the inflexibility of uncrystalline limestone as compared with other uncrystalline rocks (shales and sandstones) and its tendency, therefore, to break and become irregularly shoved up under uplifting or flexing action. Moreover, the limestone areas appear generally to be regions of anticlinals, and the schist areas those of synclinals; and the former, whatever the rock, are usually the places of greatest surface fractures, and the latter, of least. In the synclinal, the limestone beds are kept in place beneath the overlying strata; and therefore, the irregularities in the limestone should not appear close to the schist.

In such a region of extensive upturning and mountain-making as that of the Green Mountains there must be many lines of great fractures and faults. Yet the only case of non-conformity in dip adjoining a ridge of schist which I have observed occurs near the middle of the limestone region within half a mile east of Great Barrington village at the foot of the section represented in fig. 12. The limestone dips 80° to 85° to the westward; and the schist, at its nearest outcrop—10 yards—dips 50° to 60° to the eastward, the strike being N. 10° E. The schist is mostly a thick-bedded gneiss; and its antique look and massiveness, with its contorted texture, led me, in view of the non-conformity of dip, to suspect actual unconformability, and also difference in age and system of uplift. But this idea was soon set aside by the discovery that the top of the ridge was made partly of quartzyte, like that of Monument Mountain three miles north, and by other facts showing that both the schist and quartzyte were part of the limestone series.

The facts here brought forward fully establish the conclusion that the limestone, quartzyte, and schists under consideration have the same stratigraphical relations in Berkshire that they have in Vermont. They therefore sustain the view that these formations constitute together a conformable series; and, also, that the area they cover is geologically one.

[To be continued.]

ART. VII.—*On certain new and powerful means of rendering visible the Latent Photographic Image;* by M. CAREY LEA.

THE development of the latent or invisible photographic image produced by the action of light is beyond all question the most remarkable and the most interesting fact with which photo-chemistry has made us acquainted. Our knowledge, however, of the substances capable of exhibiting this power, has increased with singular slowness. It commenced with the discovery, by the late Rev. Mr. J. B. Reade, in the year 1836, of the existence of this power in *gallic acid*, and not long after *pyrogallol* was found to possess the same property in a more energetic degree. Mr. Robert Hunt discovered that *ferrous sulphate* acted somewhat more powerfully than pyrogallol, provided that a soluble salt of silver was present. This was more than twenty years ago. Since then, no useful addition has been made to this list of so-called "developers," though several of simply scientific interest. I was enabled to add to it *hœmatoxyline* about ten years since. *Morphia* has been found to have limited developing powers. When pyrogallol or gallic acid was employed in the absence of a soluble salt of silver, it was found that the activity of these bodies could be greatly increased by the presence of an alkali (alkaline development), for which purpose ammonium carbonate has been generally employed. It has been recently affirmed that in the ammonia-pyrogallol process, pyrogallol could be replaced (though with less energetic action, and therefore not advantageously) by a decoction of coffee berries, probably by reason of the quinic and caffetannic acids contained; and possibly by one or two other substances. This I believe represents the information acquired up to the present time.

In the following investigation I propose to show:

1. That the number of bodies endowed with the power of developing the latent image, so far from being very limited, as hitherto supposed, is, on the contrary, very large.

2. That contrary to what has been generally held, *potash* acts more powerfully in aiding development than ammonia; that there exist substances which develop with more or less energy in the presence of potash (e. g., mannite), but which have no such power in the presence of ammonia,* or alone.

3. It has been generally thought that the most energetic form of development, when no soluble salt of silver is present, is that which depends on the use of free alkali. I propose to show that there exists a form of development which under

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* Unless possibly after greatly prolonged exposure.

appropriate conditions is more powerful than any yet known, in which there is *no free alkali present.*

4. It has been held that ferrous salts act only in the presence of a soluble salt of silver, and scarcely attack the silver haloid in the film, to produce an image in the absence of silver nitrate or other soluble silver salt. This also I think can be disproved.

As the development of the latent image depends (in the class of cases which I shall here consider,) upon a reduction of the portions of the sensitive substance which have been acted upon by light, it is evident that it is amongst reducing agents that we must look for bodies possessing this power. But here we are at once met by the fact that it is not the reducing power alone that is involved. We find that many substances which reduce silver salts energetically, have no power to evoke the latent image, and also that the developing power, where it exists, stands in no sort of relation to the energy of the reducing power. It is an *elective* power that is required, a tendency to reduce, not the whole surface, but only those parts that have been acted upon by light, and to spare the others. For example, it is easy to prepare alkaline solutions of ferrous salts, by having present a sufficient quantity of neutral potassium tartrate. But such solutions, applied to a sensitive surface that has received sufficient exposure under a negative, or in the camera, for ordinary development, seem to attack equally those parts that have been acted upon by light and those that have not. So that the sensitive surface darkens uniformly without showing the vestige of an image. Other similar cases will appear farther on.

In the following series of investigations a pure photographic paper was selected as the material for containing the sensitive substances. In the selection of the sensitive material itself, the object was to obtain the most highly sensitive possible. Silver iodide and bromide together are more sensitive to light than either separately, but also are more subject to irregular reduction. The best means of removing this difficulty without impairing the sensitiveness, I found to be the addition of silver chloride, which previous investigations had shown me to possess this power in a very remarkable way. Accordingly the present investigation was conducted upon surfaces containing these three substances together. The proportions used were those resulting from a solution containing eight grains potassium bromide, two of potassium iodide, and one and a third ammonium chloride, to the ounce. This proportion was that which gave the best results and was maintained in the experiments throughout. Facility of development is always increased by the presence in the sensitive film of some suitable organic substance. In these investigations a decoction of *cocculus indicus* was employed: this was applied together with the haloids, first; after drying, the silver solution. Finally the sheets were very thoroughly washed out, to remove every trace of excess of silver nitrate and of all other soluble matter. To this careful washing much importance attaches. If any cocculus were left in the paper, it might, by dissolving out in the developing solution, confuse the result, inasmuch as cocculus with potash exhibits some developing powers. Every trace of it was therefore removed by the most careful washing, and as an additional precaution, the most important results were repeated on paper prepared with haloids only, in order to control the conclusions with exactness.

RESULTS.—A. *Sugars.*

Several sugars when heated with dilute aqueous solution of potash exhibit power of development. *Glucose* and *cane sugar* very slightly. *Milk sugar* produces a light metallic looking image on a dark ground. *Glycocine* was without effect. *Manna* acts very powerfully, producing an image perhaps as bold and strong as any substance hitherto known. The contrast between this strong action of mannite and the very weak action or entire inactivity of the other sugars named seemed very singular. It was thought that it might possibly arise from the fact of mannite not being a carbohydrate like the others mentioned but containing more hydrogen than sufficient to convert the oxygen into water. Therefore another sugar of the same class, *quercite*, was tried, but was found to possess no developing power whatever. The remarkably energetic action of mannite remains therefore without explanation. This substance and milk sugar, offer a good illustration of what has just been said of developing power being not necessarily proportional to reducing power. Milk sugar in conjunction with potash energetically reduces the silver haloids, but shows little developing power, while the converse is the case with mannite.

The image produced by mannite is of a redder shade than that resulting from any other developing agent.

B. *Glucosides.*

Daphnin gave a moderately strong image; its derivative, *Daphnetin*, a bolder and fuller. *Phloridzin* and *glycyrrhizin* gave no images. So-called *flavin* gave no image when simply heated with potash, but when boiled with potash and zinc turnings gave a moderately strong one, doubtless by the conversion of quercetin into *quercitrin.* Accordingly an infusion of *white oak bark* was found to give a good image. *Solanin* gave a moderately strong image, as also did *thujine.* *Colocynthine* (decoction of colocynth was used) gave little or no result. *Æsculin*, a fair image. In all cases the substance was heated with dilute aqueous potash before use.

C. *Acids.*

Of a number of organic acids tried with excess of potash, one only, *cevadic acid*, exhibited tolerable developing power. *Phenol*, and *glyceric*, and *gentianic* acids powerfully reduced the silver haloids, but with little or none of the elective power necessary to produce an image. One, *oleic*, produced an image lighter than the ground. *Santonic*, *sinapic*, *gummic*, *malic*, and *hippuric* acids produced either faint traces of an image or none at all. *Vanadous acid* (potassium vanadite with excess of potash) failed to exhibit any developing power.

D. *Resins.*

Resinous substances for the most part dissolve easily in dilute aqueous potash, and exhibit more or less developing power. Foremost among them is *guaiacum* which gives a very vigorous image, not far short of what may be obtained with pyrogallol. *Balsam of tolu* and ordinary *resin* both have moderate developing power. Resin scarcely attacks the parts that have not been acted upon by light, whereas tolu does so. Resin of *podophyllin* gives a strong image.

E. *Essential Oils.*

When *oil of cloves* is boiled for a few moments with dilute aqueous potash, and the mixture is then much diluted with water, it acts slowly on the image, but as the action is sustained and clear, there results at the end of about an hour, a vigorous and very clear image. *Oil of Roman chamomile* acts somewhat similarly, but more feebly. *Oil of peppermint* produces an image of a gold color, and at the same time darkens the parts not acted upon by light, thus producing an image on a darker ground. Something similar has been already mentioned in the case of oleic acid. In these cases, where the light acts, the developing agent seems to reduce metallic silver, elsewhere, a dark basic salt, perhaps with organic matter in combination, is formed.

F. *Bases.*

Daturin (atropin?) gives a weak image. *Codein*, none. As a general thing the organic bases exhibit little tendency to evoke the latent image.

G. *Pyrogallol.*

In the course of this investigation, some interesting and new observations were made in connection with this well known agent, that deserve mention here.

Pyrogallol is well known to have, when employed by itself, considerable developing power, which however, is greatly increased by the presence of caustic or carbonated alkalies. It appears that these alkalies can be replaced with sodium *metaphosphate*, with about equal results. With sodium *hypophosphite*, the effect is fair but inferior. But with potassium *formate*, a more energetic result is obtained than by any other method of using pyrogallol: a stronger development than by any of the methods now in use.

H. *Various.*

Trials were made with a considerable number of substances of vegetable origin whose constitution or properties seemed to indicate that they might exhibit power of development. In all cases they were boiled a few moments with dilute aqueous potash, as it was found that in that way their characteristic actions were most fully brought out. *Aloes*, *uva ursi leaves*, *areca nuts*, the bark of the *berberin tree*, *morus tinctoria*, exhibited very considerable developing power. *Gratiola*, *ipecacuanha*, *pimento nuts*, well marked power, but less than the foregoing. A decoction of *Iceland moss* exhibited the properties already described in the case of oleic acid and essential oil of peppermint. Many other substances were examined, and showed either faint traces only or absence of power, e. g., *litmus*, *carthamus*, *rutin*, *bryony*, *stavesacre*, *colchicum*, *turmeric*, *nux vomica*, *caffein*, *berberin*, etc.

Acetone, in conjunction with aqueous potash, is a powerful developer and gives a bold and vigorous image.

Aldehyde, with potash, gives no image, a result that seems somewhat remarkable.

I. *Cuprous oxide dissolved in Ammonia.*

A colorless solution of cuprous oxide in ammonia develops a strong image, and is interesting as being one of the very few entirely inorganic developers discoverable. As might be expected, its action is heightened by the presence of many organic matters.

When to a solution of cuprous oxide in ammonia, *formic acid* is added in quantity not quite sufficient to neutralize the bases, and this solution is applied to the latent image, a powerful development is obtained, resulting in a pure black image. *Lactic acid* exhibits a similar reaction, but less perfectly, and no doubt a large number of other organic acids share the same properties.

Various substances that develop in presence of potash, especially *gum guaiacum*, *gallotannic acid* and *manna*, heighten the action of the cupro-ammonia solution. Others do not, of which *picrotoxin* (*cocculus indicus*) is an example. Of all the substances named, guaiacum appeared to have the most power, and next to it, perhaps formic acid.

J. *Ferrous Salts.*

The salts of ferrous oxide have proved to be the most interesting and remarkable of all the bodies examined, in their action on the image. When a salt of silver is present in solution, to suffer reduction and to furnish silver for building up the image to be developed, as in the case of the so-called "wet process," ferrous sulphate is the most powerful developing agent known, and is accordingly, always employed. But in the absence of silver in actual solution it is powerless. It is in connection with such sensitive surfaces (i. e., those from which silver nitrate or other soluble silver salt has been removed by washing), that the present investigation is made, and I have verified this fact, already established, very carefully. A surface of sensitive paper, from which all silver compounds have been removed, may, after receiving a latent image, be left long in contact with ferrous sulphate without an image being developed.

Desirous of finding a means of applying ferrous salts to these developments, my first efforts were directed to the formation of alkaline solutions containing ferrous oxide in solution, but they did not appear to possess any power of development. I then tried ferrous oxide in combination with organic acids, and here at once most interesting results followed. Several organic salts furnished beautiful developments, among which may be especially mentioned *ferrous succinate*, *lactate* and *salicylate*. The succinate is best used by forming a slightly acid solution of ammonium succinate, and adding to it a solution of ferrous sulphate in quantity not quite sufficient to form a precipitate. Many other ferrous salts, among which may be mentioned *citrate*, *formate* and *tartrate*, give images, but much inferior to those already mentioned. The succinate and lactate develop so well that they might pass into use, were they not, as well as all other developing agents, so much exceeded by the oxalate.

Ferrous oxalate, when applied to paper sensitized in the manner already described, exhibits developing powers of a very remarkable kind. A piece of sensitized paper exposed for a very brief period to diffuse light under a negative, and then cut into two pieces and tried, the one with this development, the other with the ordinary alkaline pyrogallic development, exhibits the following differences:

The same exposure which with the alkaline pyrogallol gives a weak and sunk-in image after a protracted development, gives with ferrous oxalate a bright, bold image, and this in a much less time. The development is particularly clear and clean. The unexposed parts are not attacked: the developer possesses a great deal of that elective power previously spoken of, which causes it to react strongly on those parts which have received the influence of light, and spare those which have not.

Ferrous oxalate is easily obtained by adding a strong warm solution of oxalic acid to one of ferrous sulphate. A bright yellow precipitate falls, which continues to increase for some time, and which may easily be washed by decantation. The method of employing it is by dissolving it in an aqueous solution of neutral potassic oxalate. The latter substance is to be dissolved in about three times its weight of hot water, and the precipitated and washed ferrous oxalate is dissolved in it to saturation. A deep red solution is obtained, which for use needs only to be diluted with from five or six up to twenty or thirty times its bulk of water, according to the energy of effect desired.

An active solution of ferrous oxalate may be obtained by simply adding a solution of ferrous sulphate to one of neutral potassic oxalate, in quantity just sufficient to avoid forming a permanent precipitate. But the first described method gives the best results.

Philadelphia, May 8, 1877.

Art. VIII.—*On the possibility of Transit Observation without Personal Error*; by S. P. Langley.

The different modes of dealing with personal equation may be divided into two broad classes: (1) those which attempt to diminish or eliminate it during the act of observation, (2) those which aim to find its amount, and to apply a subsequent correction. Redier, Braun, A. S. Herschel, Wheatstone and many others, have proposed devices falling in the first category; all of which involve the use of a movable reticule, which, theoretically, should travel at the same apparent rate as the star. The mechanical difficulties of doing this accurately (considering that every star has a different apparent rate) are extreme, and they almost necessarily involve the use of delicate apparatus forming a part of the telescope. These difficulties have never been overcome,—scarcely attacked, and were they vanquished, others would remain. This method then, though perhaps still susceptible of success with skillful treatment, has not yet proved of any practical utility. A very different proposition, originally due I think to M. Faye, and made as long since as 1858, is that for the use of photography in transits. This evidently, if practicable, does away with personal error, and if the exposure be reduced to a very brief time—let us say to $0^{s}\cdot01$—it is clear that the motion of the star is immaterial, for we have its position photographed relatively to the wires, as it was at a given instant. This method has been little used, except for the sun, owing to defective light, but though not yet practicable save in limited cases, it is perhaps not too much to say that it will probably be the method of the future.

Under the second class come the ordinary procedures for the determination of relative error, or the personal equation between two observers; such as their interchange of stations, or their observing the same stars with adjacent instruments, or with the same instrument jointly, etc. These comparisons are liable to error themselves, are commonly tedious, and often compel long journeys. When successful, they give, not the absolute error, but the error as compared with another error, itself subject to an unknown variation. Unsatisfactory as all this is, however, such methods are in common use, and will remain common till better are provided. An effort in this direction has stimulated the invention of a great number of devices to enable the observer to determine his equation by comparison with the transit of an artificial star, itself, self-recording. This suggestion (said to have been first made by Prazmowski in 1854), has been the parent of many attempts, among which those of M.M. Hirsch and Plantamour, and that of M. Wolf of the Paris Observatory, particularly deserve attention; and of subsequent ones too numerous for description, though the apparatus of Professor Eastman, U. S. N., and of Professor Rogers of Harvard College Observatory, may be cited as favorable examples. It may be observed that the use of such apparatus, however ingenious, can only determine the personal error then and there, and can give no guarantee against its variability, which is, after all, the most formidable difficulty. Were this a history of devices for correcting or eliminating personal equation, a volume might be easily filled with an account of proposals coming under one or the other of these two heads, for the literature of the subject is fuller than most are aware.

To propose to offer anything new at this day on such a subject may seem to be hardy. I venture however to ask attention to a method for eliminating the equation on the star itself, which has worked well on trial.

Before stating it, let us observe that we restrict the words "personal equation" here, to the correction for the error committed by the observer in noting the time of transit of a star owing to the motion of the latter, and that for brevity we leave untouched the effect of certain minute irregularities familiar to the observer, such as the actual inequality of wire intervals which should be equal, or the apparent irregularity in the motion of the star due to atmospheric tremor. A particular interest in the subject has long led me with others, to try to remove the error from the observation, in the act of observation itself. One mode which presented itself many years since, and which has been tried in numerous subsequent plans I have made, was to view the star only for a brief time through a narrow linear aperture in a moving screen, thus exhibiting its position in the field for a moment only, though the use of a flash of light which for an instant illuminates the wires has seemed better. In any case the essential idea was to treat the eye as it has been proposed to use the photographic plate, and to impress upon it by instantaneous vision an image of the position of the star independent of personal error (in one sense,) since the star was to have sensibly no time to move, while the view lasted, while yet the effect then seen would remain (owing to persistence of vision,) quite long enough for cognizance. After a great number of forms of the movable screen were considered, they were set aside for the flash of light from the electric spark.

To make the present plan plain, let us recur to the use of photography as an illustration, and first suppose that the transit wires are twenty-five in number and so near that a star occupies one second in passing from one to another. In the place of a transit lamp, let a wire, attached to a repeater in the clock circuit, dip in a mercury cup, and the circuit being broken every second by the clock, recording simultaneously on the chronograph; the otherwise dark field will be illuminated by a brilliant instantaneous flash, by whose light the wires are projected with the crossing star on the sensitive plate of the camera. If this plate be renewed or moved downward at each flash, we obtain twenty-four successive pictures while the star is crossing, each showing it at the extremity of its luminous traces in precisely the same relation to the adjacent wires, since the wire interval in time, and the flash interval, are identical. If then the star is caught by the first flash, one-third of the way from the first to the second wire, it will be exhibited by the next flash one-third the way from the second to the third, and so on. Any one of these photographic pictures would on being measured, and compared with the chronographic record give the time of transit free of personal error, but this method, applicable if at all, at present, only to the brighter stars, is here used only in illustration. Even were it practicable we do not always have a photographer or photographic material at command, but we have the eye at all times, and I hope to show how we may obtain from it, results of the same order of accuracy as those we could expect from the photograph, and equally exempt from personal error, in the sense in which we have defined it.

First as to the difficulties to overcome. In the case of the photograph, there is an opportunity for subsequently measuring the distance of the star from the wire, which we have not with the eye. There is one particular case however, where the result is the same for both, that, namely, when the flash comes, the star is on the wire and bisected by it; in this case we know its position as accurately by the eye, as if we bisected its image on the plate by the wire of our measuring micrometer, with the same magnifying power. If we suppose, then, that the star observed was in the equator, and that, by a happy accident, the first flash came just as it was crossing the first wire, this wire would be sharply defined on the disc of the star and bisecting it, and the simultaneous record on the chronograph (made without any intervention of the observer) would evidently give us the same result as though the star had electrically recorded its own passage. Further, we may particularly notice that it is immaterial whether the star was at rest, when thus seen, or in motion. Now what we have just supposed as the single case of a favorable chance among hundreds for an equatorial star; with wire intervals of one second, it will be our task to *make* occur, whatever the wire interval, and for any star observed; and that our invention may be of practical utility, to find apparatus, whose use requires no unreasonable demand on the observer's time or skill, and which is simple and portable. After numerous failures, the following apparatus was devised a year since, but it has only been constructed and put to trial with promising success at this Observatory within the last month. In the described form it is especially intended for longitude work, where it is necessary to determine the clock error from time stars (whose declination does not exceed 60°), and most desirable that the results shall be independent of that personal error in the observer, which presents itself on this class from the star's rapid motion.

On the transit pier (or in any other convenient locality) is a small clock, with a conical pendulum, whose bob slides freely up and down the graduated rod, retaining its position where left. A small horizontal wheel in the clock is controlled by the pendulum, and turns once for a certain constant number of its revolutions. This wheel revolves once for each equatorial interval of the transit wires, when the bob is set at a mark near the top of the rod, and by sliding the bob sufficiently downward; with the use of a readily-constructed table, we can, given the declination of any star between the limits 0° and ± 60°, set the pendulum, so that this wheel shall make exactly one revolution while the star passes from wire to wire. This wheel carries near its periphery a mercury drop or other contact piece, which once in a revolution is carried past a point fixed near the periphery of a stationary horizontal wheel, concentric with the first, and immediately above it, but insulated and entirely detached from it. This upper wheel, while thus related to the lower, is entirely disconnected from the machinery of the clock, and is thus far stationary, but it can be revolved by cords passing from a groove in its circumference to the hand of the observer at the transit. As the upper, or ordinarily fixed, and the lower or constantly moving, wheel have, a common vertical axis of revolution, and as the radial distance of the point in the upper from this axis is the same as that of the contact piece on the lower, it will be seen while the upper wheel remains motionless, electric contact accompanied by a simultaneous flash, if we desire it, at the transit lantern or elsewhere, will be made at equal and uniformly recurrent epochs, the interval between which depends only on the adjustment of the pendulum. If the upper wheel be rotated forward by hand, through a small distance, and then left, the next contact will still occur, but at a later epoch, owing to the lower wheel's having to complete more than one revolution to make contact, but after this the contact and simultaneous flash will recur at the same intervals, and with the same regularity as before. If the upper wheel be moved backward, the flash will occur once, earlier, and thereafter with regularity. Moving the upper wheel, then, changes the epoch from which any series of such flashes dates and adjusting the pendulum bob, fixes the interval between subsequent flashes. In practice the lamp is removed from the transit lantern, and the two terminals of a battery or induction coil in its place, cause the flash to be thrown upon the wires, whenever the mercury drop is in contact with the point, and at the same instant a mark is made automatically on the chronograph and interpolated in the regular record of the beats of the sidereal clock, which go on in the usual way quite independently of any reference to the apparatus just described. The method of connecting the wires so as to give these results, will so readily suggest itself to the practiced observer that we need not occupy our present general description with it. I here speak of the instrument in actual use, where the contact piece makes circuit, but a break circuit is easily substituted, and we may use a Geissler tube in place of the spark.

The mode of observation will be anticipated. Before the transit of any star the observer adjusts the conical pendulum beside him (this is the work of but a few seconds), and then seats himself at the instrument holding the cords in one hand like the "reins" of an equatorial. If a flash occur just as a star is crossing the first wire (which is most unlikely) he has nothing to do, except possibly to note which was the middle wire, for each records itself on the chronograph without any intervention of his. But if the star be, for instance, two-thirds of the way from the first to the second wire at the first flash, he will draw one of the cords, accelerating the flash and thus causing the star to appear nearly coincident with the second wire when the next spark comes, and repeat the adjustment by the light of subsequent flashes, till the bisection is perfect. Three or four trials are in practice found to yield a bisection which will satisfy a fastidious eye, and when a satisfactory one has been once made, the effect is automatically repeated. Of course, no increase in number of the wires, under these circumstances, adds real weight to that from the first satisfactory bisection, but, with the usual five tallies of five wires each, the observer can easily, if he please, obtain five independent bisections,* or one for each tally, and in this case the chronographic record corresponding to the last wire of each tally is assumed to be the significant one, unless the contrary is recorded.

Under the general conception, then, of the possibility of diminishing to any limit personal error, by employing brief views of the star or wire and utilizing the phenomena of persistence of vision, the particularly described device assumes to dispense with the observer's record upon the chronograph altogether, and to substitute a purely automatic one, giving the same virtual result as though the image of the star were a tangible object, itself making electric contact with each wire. The share of personality in any observation, is relegated to the prior act of bisecting a star, virtually motionless with relation to the bisecting wire, so that if (as seems to be the case) this act is independent of quickness or slowness of perception, of the time of cognition, or of the speed of nerve transmission; personality in the technical sense, appears not to intervene at all.

ART. IX.—*Observations of Comets made at the Litchfield Observatory of Hamilton College*; by C. H. F. PETERS.

1. *Comet* 1877, II (Winnecke's):

1877.	Mean t. H. C.			App. AR.			App. Dec.			No. of Comp.
Apr. 6.	16^{h}	18^{m}	56^{s}	22^{h}	8^{m}	$46{\cdot}29^{s}$	+16°	23′	12·7″	10
" 8.	15	39	25	22	10	23·76	18	46	6·0	10
" 10.	15	25	24	22	12	13·71	21	22	7·2	10
" 12.	15	30	34	22	14	18·84	24	10	11·5	10
" 14.	14	54	27	22	16	36·48	27	7	9·8	14
" 23.	14	8	32	22	32	39·34	43	3	33·9	10
May 2.	14	0	48	23	12	23·07	62	25	28·1	10
" 12.	13	11	17	2	50	42·20	79	48	19·5	8
" 13.	12	46	23	3	38	25·44	80	10	32·7	8
" 14.	9	58	52	4	21	43·23	80	8	25·0	8
" 29.	12	2	6	8	41	11·96	+62	21	31·6	9

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* I regret that this lengthy description may convey an impression of complexity as to a really very simple apparatus, all we ask of which, as a timekeeper, is that its rate shall be sensibly constant during the star's brief passage through the field. It consists only of a small conical pendulum with maintaining power and the two contact wheels described. Its installation consists in placing it in a level position and connecting it with the wires, and its size need not exceed that of the break-circuit chronometer box; it may indeed for field-work be conveniently encased with the latter.

Notes.—This comet showed always a fine star-like concentration of light, which permitted an accurate pointing, so that the observations are good. The tail was never very bright, but the coma large. Instead of forming an envelope, as there seemed to be a tendency on April 8, the denser portion of the coma on May 2 appeared to consist of small discrete particles, exactly like a star cluster or nebula just at the point of being dissolved.

2. *Comet* 1877, III (Swift-Borelly's):

1877.	Mean t. H. C.	App. AR.	App. Decl.	No. of Comp.
May 3.	11^h 6^m 23^s	* — $25{\cdot}80^s$	----	6
" 3.	10 56 31	----	* $-2'$ $22{\cdot}0''$	4
" 4.	10 3 5	5^h 3^m 25·93	$+60°$ $2'$ 25·1	8
" 5.	10 10 38	5 15 50·04	59 30 24·7	8
" 12.	10 6 41	6 29 25·59	54 7 31·2	10
" 30.	9 58 1	8 13 1·60	+35 45 34·3	10

The comparison star for May 3 is D'm. $+60^{\circ}$,854, and its position 1877·0 approximately $\alpha = 4^h\ 51^m\ 42^s$; $\delta = +60°31{\cdot}2$.

The observations of May 3, 4 and 5 were made by Professor J. G. Porter with the ring micrometer of the four-inch Steinheil refractor. All the other observations were obtained by myself with the filar micrometer of the 13½ inch refractor, using a power of 270, and illuminated wires.

Comet III had always a more or less blurred aspect, without distinct nucleus, rendering the pointing difficult.

Clinton, N. Y., June 1, 1877.

Art. X.—*On Complex Inorganic Acids.* From a letter of Dr. Wolcott Gibbs to one of the Editors, dated Cambridge, June 14th, 1877.

You will doubtless remember that about twelve years since Marignac described three acids which he obtained by boiling silicic hydrate, $Si(OH)_4$, with an acid alkaline tungstate, and which he called respectively silico-tungstic, tungsto-silicic and silico-deci-tungstic acid. The two first mentioned are isomeric or metameric, and are represented by the formulas:

$$12WO_3.SiO_2.4OH_2, \text{ or } W_{12}O_{34}Si(OH)_8,$$

while the third has the formula

$$10WO_3.SiO_2.4OH_2 \text{ or } W_{10}O_{28}Si(OH)_8.$$

It occurred to me that these results might be generalized in various ways, and I have in fact obtained some very interesting new series of acids of the same or similar types. Platinic hydrate $Pt(OH)_4$ boiled with an acid sodic tungstate yields two isomeric or metameric sodium salts which have the formula:

$$10WO_3.PtO_2.4ONa_2 + 25 \text{ aq.}$$

One of these gives magnificent olive-green crystals; the other equally fine honey-yellow prisms with a very strong adamantine luster. They are readily soluble in water and give flocky or sub-crystalline precipitates with solutions of the heavy metals and of the higher alkaloids. The corresponding potassium and ammonium salts have respectively the formulas:

$$10WO_3 . PtO_2 . 4OK_2 + 9 \text{ aq. and } 10WO_3 . PtO_2 . 4OAm_2 + 12 \text{ aq.}$$

but both belong to the yellow series. I have not yet obtained the 12-atom series corresponding to Marignac's silico-tungstates. The platino-deci-tungstates dissolve tungstic hydrate, $W(OH)_6$, on boiling, but the hydrate separates again on cooling without change. Acid molybdate of sodium also dissolves platinic hydrate giving a deep olive-green solution which appears red in thick layers. The only salt of this series yet studied crystallizes in amber-colored tabular plates which have the formula:

$$10MoO_3 . PtO_2 . 4ONa_2 + 29 \text{ aq.}$$

They are very soluble and give sub-crystalline precipitates with many metallic solutions. I think I have also obtained the corresponding metameric series, but of this more in due time. The acids corresponding to the salts above briefly described are crystalline and may be obtained from the respective barium salts by sulphuric or from the silver salts by chlorhydric acid. Nearly all the salts of both series effloresce strongly and the alkaline salts have a very distinct acid reaction, so that the limit of the basicity is certainly higher than eight. I am endeavoring to generalize these results still farther by replacing platinic hydrate by other hydrates of the same type, as for instance by those of the other metals of the platinum group and by $Zr(OH)_4$. $Ti(OH)_4$, $Sn(OH)_4$, &c., but though I have in many cases indications of the formation of new complex acids I have nothing definite at present. Silico-molybdic acid appears however to be formed by boiling acid sodic molybdate with $Si(OH)_4$ when colorless or very pale yellow crystals are formed.

Nearly five years since Scheibler discovered two phospho-tungstic acids which, according to his analyses contained, respectively, six and twenty molecules of tungstic oxide, WO_3 to one of P_2O_5. As he has published nothing whatever upon the subject since, I have thought that I could fairly enter upon the same field and have begun the study of the 20-molecule series. I have already established some very important facts with respect to the compounds of this series, and have further generalized my own results to a most unusual extent.

According to my analyses, phospho-tungstic acid has the formula

$$20WO_3 . P_2O_5 . 8OH_2 \text{ or } W_{20}O_{57}P_2(OH)_{16}$$

independently of water of crystallization. I have obtained salts of this series having respectively the formulas:

$$20WO_3 . P_2O_5 . ONa_2 . 7OH_2 + 16 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 2BaO . 6OH_2 + 18 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 6BaO . 2OH_2 + 44 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 7OK_2 . OH_2 + 27 \text{ aq.}$$
$$20WO_3 . P_2O_5 . 8OK_2 + 18 \text{ aq.}$$

All these salts have an acid reaction except the 8-molecule potassium salt, and I consider this—provisionally at least—as determining the limit of the basicity of the acid. This is important as showing that it is not phosphoric oxide, P_2O_5, which alone is saturated. Debray considered the corresponding phospho-molybdic acid as 6-basic, but written with the newer atomic weights it would of course be regarded as 12-basic, if his view were correct. He describes however a 7-atom silver salt which I should write

$$20MoO_3 . P_2O_5 . 7OAg_2 . OH_2 + 24 \text{ aq.}$$

and which is clearly the analogue of my potash salt above mentioned. All or nearly all the phospho-tungstates effloresce quickly in dry air. I regard the formulas above given as well ascertained excepting possibly that of the very acid sodium salt which heads the list. The analyses of these salts as well as of the platinum series are difficult, and the ready efflorescence is another obstacle to very precise work. All but the first mentioned sodium salt are colorless; the 7 and 8-atom potassium salts are splendid, and there is at least one ammonium salt which is precipitated as a very heavy snow-white crystalline powder. I have not used Scheibler's method of preparing these compounds, but obtain the acid sodium salt by mixing normal sodic tungstate and hydro-disodic phosphate, $WO_4Na_2 + 2$ ag. and $PO_4Na_2H + 12$ ag., in the proportion of 20 molecules of the former to 2 of the latter and adding NO_3H until the very alkaline liquid becomes acid. I have had much success in generalizing these results. The corresponding arsenio-tungstic acid and its salts are easily obtained, and I have more or less distinct indications of vanadio-tungstic and antimonio-tungstic acids. It may prove that there are also niobio-tungstic and tantalo-tungstic acids, and experiment will soon decide this point. But generalization is also possible in other ways. Thus I find that when in my process oxyfluo-tungstate of sodium, $WO_2F_4Na_2$, is substituted for the normal tungstate, splendid crystalline salts are formed with both arsenates and phosphates. In place of normal sodic arsenate the oxyfluo-arsenate may be employed and new acids result both with normal tungstate and oxyfluo-tungstate of sodium. The same statements are probably true with respect to molybdic compounds, only the resulting salts are not always well defined. You see that in this way the number of new acids is very great and that I have a heavy task before me. It is of course too soon to speculate on the theoretical structure of the new acids. I have given the simplest possible formulas in all cases, but it may be that those of the platino-tungstic and platino-molybdic acids must be doubled. In this case their analogy to the phospho-tungstates, &c., will be more easily seen, as we shall have for the sodium salts for instance,

$$20WO_3 . Pt_2O_4 . 8ONa_2, \text{ and } 20\, WO_3 . P_2O_5 . 8ONa_2,$$

meantime I have as yet seen no satisfactory reason for the change. I am disposed to think that the well known and very singular $\frac{3}{7}$ tungstates and molybdates, $3ONa_2 . 7WO_3$ and $3ONa_2 . 7MoO_3$, should be multiplied by 3 and written

$$20WO_3 . WO_3 . 9ONa_2, \text{ and } 20MoO_3 . MoO_3 . 9ONa_2.$$

They will then fall naturally into the 20-atom series. It seems also possible that the curious salt of Wöhler usually written $WO_4Na_2+W_2O_5$ may be represented by such a formula as $16WO_3 . 4WO_2 . 7ONa_2$ or $W_{20} . W . O_{49}(ONa)_{14}$. I shall devote myself to these compounds until I have exhausted the subject as far as possible, and meantime anticipate many new results.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Effect of Pressure on Chemical action.*—**Berthelot** calls attention to Quincke's statement that in some experiments which he made in which sulphuric acid and zinc were placed in contact, the pressure of the evolved hydrogen rose in a few days from 1½ to 10 atmospheres (varying with the apparatus), in five months from 27 to 54 atmospheres, and in 17 years, from 25 to 126 atmospheres, and remarks that these experiments, made for an entirely different purpose, conclusively prove that the evolution of hydrogen is not arrested by pressure, but is only diminished in rapidity, confirming his results of twelve years ago. In this case, chemism is not modified, but only the nature and extent of the surface of attack, the metal becoming covered with an adherent gaseous layer, while the acid close to it becomes saturated. Hence, in his opinion, the evolution of hydrogen would go on indefinitely, limited in time only by the strength of the vessels containing the reagents.—*Bull. Soc. Ch.*, II, xxvii, 347, April, 1877. G. F. B.

2. *New method of determining the Specific gravity of a readily decomposable body.*—In order to determine the specific gravity of iodine trichloride, a body not only exceedingly volatile at low temperatures, but also readily dissociated except in presence of chlorine gas, **Christomanos** has devised a new and simple method for this purpose. In a cylindrical glass vessel closed at the ends by two suitable glass cocks and previously filled with dry chlorine gas, and weighed, the trichloride is placed and the weighing is repeated. The difference in weight is the weight of the trichloride less the weight of chlorine equal in volume to it. To determine this latter weight and thus the volume of this chlorine (which of course is the volume occupied by the trichloride) the experiment is repeated at a suitable temperature using carbon dioxide in place of chlorine. From this second difference, the known weight-relations between the gases being given, the weight of the chlorine is obtained by means of the formula $Cl=\frac{71}{27}(c_1-b_1-c+b)$ in which b and b_1, c and c_1 represent the first and second weighings with chlorine and carbon dioxide respectively. This weight

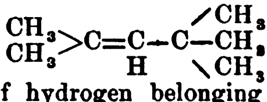
known, the volume is calculable at the temperature and pressure of the experiment, and hence the volume V of the trichloride is known. Its weight, W, $=\frac{27}{71(c_1-b_1)-44(c-b)}$, in grams. From these data, the density is obtained since $\frac{V}{W}=D$. The result with ICl_3 gave 3·1107, which the author thinks too high.—*Ber. Berl. Chem. Ges.*, x, 782, May, 1877. G. F. B.

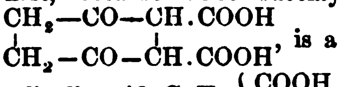
3. *On the Determination of High Melting Points.*—CARNELLEY has proposed a new process for fixing the melting points of less readily fusible salts, founded on the principle that if three metallic salts A, B and C, which fuse at different temperatures such that A fuses before B and B before C, be arranged on a cold block of smooth iron and this be placed in a muffle kept at a constant high temperature, and if x be the number of seconds which elapse between the melting of A and B and y, the number of seconds between the melting of A and C, then the ratio $\frac{y}{x}$ is approximately constant for the same three salts whatever may be the temperature of the muffle, provided only it is considerably higher than that at which C fuses. Thus in sixteen experiments, using the three substances, sulphur, silver nitrate and potassium nitrate, the experiments being made at widely different temperatures, the ratio in each was 2·67, 2·68, 2·81, 2·80, 2·72, 2·67, 2·67, 2·67, 2·56, 2·62, 2·58, 2·87, 2·65, 2·88, 2·71, 2·91; mean 2·72. If the ratios obtained with different salts be reduced to the same scale, as by assuming the ratio between sulphur and potassium nitrate and any other third salt to be any given number, the value for a given salt is constant, whatever the other salts used with it in the experiment. From these ratios, time-values are obtained for nine standard salts, S, $AgNO_3$, KNO_3, $KClO_3$, $TlCl$, $PbCl_2$, KI, KCl, and Na_2CO_3. Thus if in four experiments, 27, 39, 45, and 65 seconds respectively elapse between the melting of S and $AgNO_3$, and 72, 106, 120, and 170 between S and KNO_3, then if we assume a constant value, say 10 seconds, for the former, the latter becomes constant; i. e., 26·7, 27·2, 26·7, 26·7 seconds. This (or the mean of a larger series 26·4) is the "time-value" for KNO_3. So 32 is the time value for $KClO_3$, 45 for TlCl, 59 for $PbCl_2$, 115 for KI, 197 for KCl, and 258 for Na_2CO_3. From the equation $\frac{y}{x}=r$, in which r is the experimental ratio for any salt, the time-value of that salt may be obtained. Thus with S, $AgNO_3$ and $KClO_3$, if $r=2·72$, $\frac{y}{x}=2·72$; whence if $x=10$, $y=27·2$, the time-value. Or, again, the value of r for $PbCl_2$, KCl and Na_2CO_3 is 1·50. Since the time-values of the two former are 59 and 197, $x=138$, and $y=207$; or Na_2CO_3 melts 207 seconds after $PbCl_2$; and since $PbCl_2$ melts 59 seconds after S, the time-value of Na_2CO_3 is 266 seconds. By accurately determining the melting points of these nine salts, and collating

them with their time-values, a table may be obtained from these data, either by direct or by graphic interpolation, from which, knowing the time-value for any salt, its melting-point can be obtained.—*Jour. Chem. Soc.*, xxxi, 365, April, 1877. G. F. B.

4. *New Vapor Density Method.*—Goldschmiedt and Ciamician have modified somewhat Victor Meyer's method of fixing vapor densities, and by substituting mercury for fusible metal, have contrived an apparatus which is simple and effective. A glass bulb of 150 c.c. capacity has at its lower portion a tube which turns and passes upward to about the diameter of the bulb above it, and to which, just below its top is attached a lateral tube. A weighed substance being placed in the bulb, this is filled with mercury till it flows away by the lateral tube. The whole is placed in a bath of water or paraffin as is necessary, and heated. The production of vapor expels its volume of mercury which is received in a tarred vessel and weighed. This volume corrected is the volume of the vapor; whence its vapor is the quotient of its weight by this.—*Ber. Berl. Chem. Ges.*, x, 641, April, 1877.

G. F. B.

5. *On the Condensation of Isobutylene.*—Boutlerow has obtained a curious body, which he calls isodibutylene, by the action of diluted sulphuric acid upon trimethylcarbinol. It is a colorless liquid, having a boiling point between 102° and 104°, and is by its chemical characters, a hydrocarbon of the ethylene series, forming direct addition products with bromine, with hydrochloric and with hydriodic acids. Moist silver oxide acts on the iodide thus obtained, giving rise to a new octyl alcohol, isodibutol, having a characteristic smell of camphor, and boiling at 146·5°–147·5°. When isodibutylene or isodibutol is oxidized with chromic acid, the principal products are acetone and trimethyl-acetic ether; hence the constitution of the hydrocarbon is represented by the formula  $\begin{matrix}CH_3\\CH_3\end{matrix}\!>\!C=\underset{H}{C}-C\begin{matrix}\diagup CH_3\\-CH_3\\\diagdown CH_3\end{matrix}$. It is isobutylene, in which an atom of hydrogen belonging apparently to the methylene group, is replaced by tertiary butyl.—*Bull. Soc. Ch.*, II, xxvii, 370, April, 1877. G. F. B.

6. *New method of producing Salicylic acid.*—Hermann, who studied some time ago the action of sodium on succinic ether, now finds that if the action be long continued, there is formed, probably by the action of the metal on the succinyl-succinic ether at first produced, considerable quantities of salicylic acid. The production of this substance in this way is doubly interesting; first, because since succinyl-succinic acid, whose formula is  $\begin{matrix}CH_2-CO-CH.COOH\\|\qquad\qquad\qquad|\qquad\qquad\\CH_2-CO-CH.COOH\end{matrix}$, is a member of the fatty series, while salicylic acid, $C_6H_4\left\{\begin{matrix}COOH\\OH\end{matrix}\right.$ belongs to the aromatic, it shows a conversion of one into the other, the closed ring of six carbon atoms in the former suffering a further condensation and develop-

ing a true benzene ring; and second because from this mode of formation it is clear that in salicylic acid the hydroxyl and the carboxyl groups occupy the para position.—*Ber. Berl. Chem. Ges.*, x, 646, April, 1877. G. F. B.

7. *On the Formation of Coumarin, and of Cinnamic and other analogous acids.* — PERKIN, who synthesized coumarin $C_6H_3\left\{\begin{matrix}C_2H_3O\\CO\end{matrix}\right.$ several years ago, now finds that this substance is readily produced when salicyl hydride is boiled with acetic oxide and sodium acetate. He was thus led to try other aldehydes in the same way. On boiling benzoic aldehyde with acetic oxide and sodium acetate for a day, a considerable quantity of an acid was obtained which on examination proved to be cinnamic or phenyl-acrylic acid $C_6H_5.CH.CH.COOH$. Using propionic oxide and sodium propionate, the product of the reaction was phenyl-crotonic acid, $\left\{\begin{matrix}CH_2(C_2H_2C_6H_5)\\|\\CO(OH)\end{matrix}\right.$. From butyric acid and sodium butyrate, was obtained phenyl-angelic acid, $\begin{matrix}CH_2(C_3H_4.C_6H_5)\\|\\CO(OH)\end{matrix}$. From benzoic aldehyde, succinic acid and sodium succinate, isophenyl-crotonic acid. From cuminic aldehyde, acetic oxide and sodium acetate, cumenyl-acrylic or isopropylphenylacrylic acid $C_6H_4(C_3H_7).C_2H_2.COOH$, was obtained. Substituting propionic oxide gave cumenylcrotonic acid, while butyric oxide gave cumenylangelic acid. Cinnamic aldehyde with acetic oxide and sodium acetate gave cinnamenylacrylic acid, propionic oxide gave cinnamenylcrotonic acid, and butyric oxide gave cinnamenylangelic acid. Anisic aldehyde gave methylparoxyphenylacrylic, methylparoxyphenylcrotonic and methylparoxyphenylangelic acids, when thus treated. Methylsalicylic aldehyde gave methylorthoxyphenylacrylic, methylorthoxyphenylcrotonic and methylorthoxyphenylangelic acids.—*J. Chem. Soc.*, xxxi, 388, April, 1877. G. F. B.

8. *New Urea reaction.*—SCHIFF has observed that when a solution of urea in three parts of a concentrated aqueous solution of furfurol is treated with a few drops of hydrochloric acid and warmed, a splendid purple-violet color is developed.—*Ber. Berl. Chem. Ges.*, x, 773, May, 1877. G. F. B.

9. *Notes from the Chemical Laboratory of the Johns Hopkins University.* Nos. 1, 2, 3. 16 pp. 8vo: Baltimore, May, 1877.—The papers here included are: Oxidation of Mesitylene-sulphonic acid, by L. B. HALL and Professor REMSEN; on the oxidation of the Sulphoacids derived from metaxylene, by M. W. ILES and Professor REMSEN; on isomeric nitrotoluenesulphonic acids from paranitrotoluene, by E. HART and Professor REMSEN.

II. GEOLOGY AND MINERALOGY.

1. *Volcanic Eruptions on Hawaii;* by Rev. TITUS COAN.—On the 6th and 7th of January, 1873, the great terminal pit of Mauna Loa, Mokua-weo-weo, was intensely active, exciting the attention of spectators around all the shores of Hawaii and Maui. The scene was brilliant beyond what I had ever before witnessed in that lofty crater. But it was as transient as it was bright. We were favored with only two nocturnal exhibitions, when the curtain dropped and the lights were extinguished.

On the 20th of April, 1873, this crater fired up again, and for months the illumination was grand by night, and the column of smoke and gases rose in a magnificent pillar by day.

In January, 1874, another marvellous boiling commenced in Mokua-weo-weo, and continued for fifteen months. During all this period parties could ascend the mountain, look down into this awful cauldron, listen to the surging and roaring, and startling detonations of the fiery abyss, and watch the jets as they spouted upward hundreds of feet, and the glowing waves as they rolled and dashed against the walls of the pit.

I think it was on the 11th of August, 1875, that another brilliant eruption occurred in Mokua-weo-weo, lighting up the firmament, and awakening the enthusiastic admiration of beholders. This continued but one week.

On the 13th of February, 1876, we were entertained by another grand display of Pele's fire-works, keeping thousands of people on the watch at midnight, but this also was of short duration.

All these demonstrations were confined to the great mountain crater. There were no overflowings and no lateral outbursts. The last eruption was on the 14th of last February, between 9 and 10 in the evening, and it was the sublimest scene we had ever witnessed about Mokua-weo-weo. The display of light was most glorious. It looked as if the summit of the mountain was melted, as if the heavens were on fire. Vast columns of illumined steam rose like flaming gases from the burning pit, rushing upward with fearful speed to the height of 14,000 to 17,000 feet, where it spread out into a vast fiery cloud, which shone down upon and lighting up Hilo as if the firmament were on fire, projecting shadows of the objects around. This continued through the night. In the morning the mountain had on a veil of thick clouds, the rain fell, and the gorgeous scene was hid from our eyes. After some days the clouds were dispersed, but no vestige of the marvellous scene remained. No smoke! no fire! on the mountain, but only an occasional subterranean thud, as of Vulcan's trip hammer, and a smoky atmosphere. So sudden and complete was the cessation, that all spectators were amazed and disappointed. People in Kau and Kona sent messages to Hilo, enquiring if we were having the eruption all to ourselves; and we sent back the inquiry to them, "What has become of the volcano?" while the mountains stood above in silent and solemn grandeur. The steamer came up to Kona and to Kau, loaded with passengers, curious to witness the eruption, but the fire had become extinguished, and they returned disappointed. But before the vessel was fairly out of sight, a remarkable bubbling was seen in the sea about three miles south of Kealakekua—where Capt. Cook fell,—and a mile from the shore. Approaching the boiling pot, it was found emitting steam and throwing up pumice and light scoria, many specimens of which were gathered. This boiling was active when we last heard. It is in deep water. On the island new fissures have been opened in the pahoihoi, which extend up to the higher lands, indicating the course of a subterranean lava stream, that terminated in a submarine eruption—a new feature in our modern volcanic phenomena. About the time of this eruption beneath the sea, a tidal or earthquake wave of considerable force was observed along the coast of Kona.—*Letter to Prof. C. S. Lyman, dated Hilo, March 17th*, 1877.

2. *Geological Survey of Pennsylvania.*—The following Reports of work in this Survey have recently been issued by the Board of Commissioners, Harrisburg.

(1) *Report of Progress in the Counties of York, Adams, Cumberland and Franklin*, illustrated by maps and cross-sections showing the magnetic and micaceous ore-belt near the western edge of the Mesozoic Sandstone, and the two Azoic systems constituting the mass of the South Mountains; with a preliminary discussion of the Dillsburg Ore-bed; by PERSIFOR FRAZER, Jr. 400 pp. 8vo, with maps and sections. 1877.

(2) *Report of Progress in the Cambria and Somerset District of the Bituminous Coal-fields*, by F. and W. G. PLATT. Part I, Cambria. 194 pp. 8vo, with 44 wood-cuts and 4 maps and sections. 1877. This report gives from "the elaborate hypsometric map of Edmund Smith yet to be published," the heights of the crests of the Allegheny Mountains, showing for the western crest a range from 2,190 to 2,810 feet; and for the outer crest, 1,490 to 2,510 feet; also those of the principal summits of Laurel Hill, 2,270 to 2,450 feet.

(3) *Special Report on the Coke Manufacture of the Youghiogheny River Valley in Fayette and Westmoreland Counties, with geological notes on the Coal and Iron-ore beds*, by FRANKLIN PLATT. To which are appended a Report on methods of Coking by John Fulton, and a Report on the use of natural gas in the Iron Manufacture, by J. P. Pearse and F. Platt. 252 pp. 8vo, with maps and plates and wood-cuts.

3. *Bulletin of the U. S. Geological and Geographical Survey of the Territories.* F. V. HAYDEN, Geologist-in-Charge. Vol. III, No. 3. This number contains the following papers: Comparative vocabulary of Utah dialects, by E. A. BARBER; on methods of making Stone Weapons, by P. SCHUMACHER; by A. C. PEALE, on a peculiar type of Eruptive Mountains; by E. D. COPE, on the Geology of the Judith River and on Vertebrate fossils from the Missouri region;

C. A. White, papers on Judith River group Unionidæ and Physidæ; Uniones and a new genus of fresh-water Gasteropoda from Tertiary of Wyoming and Utah; Comparison of the Unionidæ and associated mollusks with living species; paleontological characteristics of the Green River Cenozoic and Mesozoic; Dr. E. Coues, U. S. A., notes on American Insectivorous Mammals; Ornithology of source of Red River of Texas; S. Aughey, catalogue of land and fresh-water shells of Nebraska; A. D. Wilson, on the Geographical work of the Survey. A further notice is deferred to another number.

4. *Geological Survey of Canada*, Alfred R. C. Selwyn, Director. Report of Progress for 1875–76. 432 pp. 8vo, with maps and plates. 1877.—This volume opens with an Introductory Report, reviewing the work of the year, by Mr. Selwyn, after which come special reports: on British Columbia, by Mr. Selwyn; on the same region, by G. M. Dawson; and on other western areas, by Prof. Macoun, J. F. Whiteaves, R. W. Ells, Robert Bell, and S. Barlow; and on New Brunswick and Nova Scotia, by S. Barlow, L. W. Bailey, G. F. Matthew, R. W. Ells, and H. Fletcher; with a chemical Report, by C. Hoffmann; on the Insects of the Tertiary at Quesnel, by S. H. Scudder; and List of Coleoptera collected on the Lower Peace and Athabasca Rivers, by Prof. J. L. LeConte.

Mr. Selwyn states that Mr. H. G. Vennor has found a large variety of crystalline rocks in Western Quebec and Eastern Ontario, characterized by Eozoon, great beds of magnetite, apatite, and graphite; and that in Renfrew and Pontiac the labradorite rocks are interbedded with the lowest limestones; that these beds rest probably unconformably on the "Lower Laurentian or reddish gneiss.

Mr. Dawson describes the region between the Cascade Range and Fraser River, the 52d and 54th parallels of latitude. It contains extensive basaltic areas; porphyritic rocks of uncertain age; lignitic beds generally if not always beneath the basalts, which are "undoubtedly Tertiary;" Cretaceous rocks; besides gneisses, granites, diorytes, etc. The Report on New Brunswick, by Bailey and Matthew, describes the Silurian crystalline rocks of the Mascarene series, including chloritic rocks, diorytes, felsytes and argillytes. They are shown to be Upper Silurian.

5. *Shifting of the earth's axis.*—Prof. Haughton has a mathematical paper, on the shifting of the earth's axis caused by the elevation of the existing continents, in the Proceedings of the Royal Society, vol. xxvi, p. 51. He finds by calculation that the displacement would be as follows:

	Toward Greenwich. Miles.	Toward Behr. Str. Miles.	Toward Yucatan. Miles.	Toward Rangoon. Miles.
Europe and Asia,	----	58·7	199·4	----
Africa,	----	26·9	----	3·4
North America,	15·2	----	----	105·5
South America,	19·9	----	35·1	----
Australia,	----	30·2	----	30·2

The power of Europe and Asia in moving the pole is partly due to the extension of this continent along the parallel of 45°, which is the most effective latitude.

6. *Samarskite of North Carolina.*—A letter to one of the editors, from J. Lawrence Smith, dated Louisville, June 15, states that he "has succeeded in detecting and separating thoria from the North Carolina Samarskite, in which it exists to the extent of a few tenths of one per cent." And that he has discovered a new method of separating thoria from the mixed earths, easily used, and giving accurate results even when the amount present is very small.

7. *Analysis of Samarskite by Miss Ellen H. Swallow.*—The analysis of Miss Swallow (now Mrs. Professor R. H. Richards), cited on page 364 of volume xiii of this Journal, contains errors, and is therefore here given as published in the Proceedings of the Boston Society of Natural History, vol. xvii, p. 424.

Metallic acids of the tantalic group	54·96
Oxide of tin	0·16
Oxide of uranium	9·91
Oxide of iron	14·02
Oxide of manganese	0·91
Oxide of cerium (La, Di)	5·17
Yttria	12·84
Magnesia	0·52
Insoluble residue from the oxalate of cerium	1·25
Loss on ignition	0·66
	100·40

The loss was determined on another sample of the mineral.

III. BOTANY AND ZOOLOGY.

1. *On the Development and Systematic Arrangement of the Pithophoraceæ.* By VEIT BRECHER WITTROCK. Upsala, 1877. 4to.—In this pamphlet the writer gives an account of certain species from tropical countries, which had previously been placed in the genus *Cladophora.* Instead, however, of producing zoöspores as is the case with species of *Cladophora*, the upper portion of the cells swells and the contents pass into the swollen portion, leaving the rest empty. A cell wall is then formed, cutting off the swollen portion from the rest, and the spore is thus formed. It may be noticed as an innovation that the article is written in English. This practice is of late rather common in Scandinavia. It is to be hoped that this example will be imitated by others, since it not unfrequently happens that Swedish botanists do not receive full credit for their work, owing either to the small number of foreigners who read Swedish, or to the imperfect adaptability of Latin to modern scientific writing. W. G. F.

2. *Ueber Sprossung der Moosfrüchte und den Generationswechsel der Thallophyten.* N. PRINGSHEIM.—An important paper, in which the writer shows that protonemata, precisely similar to the ordinary protonemata produced from the spores, may be made to

grow directly from the setæ of mosses. The latter part of the article in which Pringsheim discusses the alternation of generations in Thallophytes is excessively recondite and difficult to follow.

W. G. F.

3. *Algæ Exsiccatæ Americæ Borealis;* curantibus W. G. FARLOW, C. L. ANDERSON, D. C. EATON, editæ. Fasciculus I. Bostoniæ, 1877.—Nothing helps the student of seaweeds like specimens, and fortunately in no department of botany are specimens so attractive. To help our own students and amateurs in this respect, and also to make known to foreign algologists, in an authentic way, the importance of our authors' own collections and studies in this department, they have combined to issue sets of specimens, with printed tickets, &c. This first fasciculus contains fifty species, all of real interest, many of them new or next to new, at least in collections. The specimens are full and beautiful, and the fasciculus is in every way attractively prepared. We have no announcement of the price, but we understand that a limited number of copies are to be put on sale. Professor Eaton at Yale College, Professor Farlow at Harvard, and Dr. Anderson at Santa Cruz, California, could be applied to by those who wish to obtain these sets. Algæ from the Californian coast have until now been unattainable; and those from Florida almost equally so since the late Dr. Harvey's time. The few species from our New England coast are all choice and rare, being such as *Lomentaria rosea*, *Hormactis Farlowii* of Bornet, *Lingbya Wollei*, a new fresh-water species by Farlow, *L. nigrescens*, *Calothrix crustacea* and *C. pulvinata.* Among the Californian species of Dr. Anderson's collection is Agardh's *Farlowia compressa.* A. G.

4. *Orchis rotundifolia* of Pursh, which Richardson referred to *Habenaria* (it was confidently supposed with good reason), and Lindley after him to *Platanthera*, is a genuine *Orchis*, having a pouch to the pollinia-disks as manifest as that of *O. spectabilis.* This is seen in fresh flowers of the living plant sent by Mr. Pringle from Vermont to the Cambridge Botanic Garden. A. G.

5. *Beiträge zur Entwickelungsgeschichte der Flechten. Heft.* I, *Ueber die geschlechtliche Fortpflanzung der Collemaceen.*—E. STAHL. Leipzig, 8vo, pp. 55.—This important contribution on the reproductive organs of lichens, forms the first portion of a work of which the author gave a preliminary notice in the Botanische Zeitung, 1874, p. 177. He has avoided any discussion of the Schwendener theory with regard to the gonidia and has sought in the study of the reproductive organs of lichens to discover their relationship to other groups. In part first, he treats of *Collema mycrophyllum* and other species of *Collema*, *Physma*, etc. The reproductive organs consist of spermatia, male, and carpogonia, female. The anatomy of the former has been known for some time, but the latter organs are now described for the first time. The carpogonia consists of two portions, the ascogone and the trichogyne. The ascogone is a coiled filament composed of several cells and is in all respects similar to the body of the same name in

the ascomycetous fungi. The trichogyne, also composed of several cells, is a more slender filament which proceeds outwards from the ascogone until it makes its way to the surface of the thallus. The experience of Stahl shows that the trichogynes seek the surface in that part of the thallus exposed to the light. In the majority of cases the spermatia and carpogonia are distinct. In the genus *Physma*, however, the ascogone is in the base of the same cavity in which the spermatia are found, a condition which Stahl maintains must prove conclusively that the spermatia are really organs of the lichen itself and not parasitic organizations as some have supposed. Stahl has often seen the spermatia attached to the exposed tip of the trichogyne, but exactly how they are attached is a difficult point to determine owing to their small size. He is inclined to believe that the process of union is similar to that which takes place in the *Florideæ*. In consequence of this union, a change takes place in the ascogone by which the asci are formed, as in the *ascomycetes*. The whole question is very candidly discussed and well illustrated by four plates. W. G. F.

6. *North American Starfishes;* Vol. V, No. 1, *of the Memoirs of the Museum of Comparative Zoology*, by ALEXANDER AGASSIZ. Cambridge, June, 1877. 137 pp. 4to, with 20 plates.—The plates, which are excellent, were drawn on stone more than twelve years ago, to illustrate a fifth volume of the Contributions to Zoölogy, by Professor Agassiz, which, unfortunately, was not completed. The first part of the volume, relating to the embryology of starfishes, was published separately by Mr. A. Agassiz in 1864, and is reprinted in the present volume with such additions as the progress of discovery has made necessary. The remainder of the volume is devoted to descriptions, especially of the hard parts, of various species (belonging to Asterias, Echinaster, Crossaster, Pycnopodia, Brisinga, Luidia, Asterina, Asteropsis, Pentaceros, Solaster, Cribrella, Astropecten) most of which are beautifully illustrated. An important chapter is also devoted to the homologies of Echinoderms. A. E. V.

7. *Ninth Annual Report on the noxious and beneficial and other insects of the State of Missouri;* by C. V. RILEY, State Entomologist. 130 pp. 8vo, with many figures and a map. Jefferson City, Mo., 1877.—Mr. Riley's report like its predecessors, is eminently practical as well as scientific. It treats of the worms that infest the Gooseberry, Currant, Strawberry and White Pine; of the Colorado Potato-Beetle, the Army Worm, the Wheat-head Army Worm, and the Rocky Mountain Locust; and also of the "innoxious Insects" the Hellgrammite and Yucca Borer. Of the Colorado beetle Mr. Riley remarks that its eastward progress was at the average rate of eighty-eight miles a year (though not over fifty miles a year over the region west of the Mississippi), and that it has now invaded nearly 1,500,000 square miles, or more than one-third the area of the United States. It does not thrive where the thermometer reaches near 100° F., and hence "it may never extend its range very far south of the territory now occupied;" but its northern spread is not limited, and it may push to the

northernmost limit of the potato-growing country—a limit which it has already well nigh reached. It travels by means of wings. But "it undoubtedly availed itself to no considerable extent, of every means of transportation afforded to other travelers, and often got a lift on eastward bound trains; and it most probably crossed the more barren plains bordering its native confines through man's direct agency, that is, by being carried." "Even the winds and waters aided its progress."

8. *Bulletin of the U. S. Entomological Commission—U. S. Geol. and Geogr. Survey*,—No. 1, 12 pp. and No. 2, 14 pp. 8vo.—The Entomological Commission consists of C. V. RILEY, A. S. PACKARD, Jr., and CYRUS THOMAS. Their first bulletin treats of the methods of destruction of the young or unfledged locusts; and No. 2 of their natural history and habits in the young unfledged state, with wood-cuts, and a map of the region east of the Rocky Mountains overrun by the insect.

IV. ASTRONOMY.

1. *Astronomical and Meteorological Observations made during the year* 1874 *at the U. S. N. Observatory*, *Rear-Admiral* DAVIS, *Supt.* Washington, 1877.—This volume contains the observations of the year 1874 at the Naval Observatory, with the reduced results. The astronomical work has been mostly done by means of the three instruments, the transit circle, the 26-inch equatorial, and the mural circle. The latter instrument has been under the charge of Prof. Yarnall, who is preparing a revised edition of the general catalogue of stars observed at the Observatory. There are two appendices to the volume: I. Instruments and Publications of the U. S. N. Observatory (see p. 242, vol. xiii, of this Journal), illustrated with heliotypes of the instruments; II. Report on the difference of longitude between Washington and Ogden, Utah, by Professor Eastman. This difference is found to be $2^h\ 19^m\ 47^s{\cdot}41$. H. A. N.

2. *Relative ages of the Sun and certain fixed Stars.*—Professor KIRKWOOD closes a communication upon this subject to the American Philosophical Society with the following summary of his conclusions:

(1.) The history of the solar system is comprised within twenty or thirty millions of years.

(2.) From the fact that the larger component of Alpha Centauri radiates twice as much light as the sun while the mass of the former is *less* than that of the latter, we infer the probability that our solar system is the more advanced in its physical history.

(3.) 61 Cygni seems to have reached a greater degree of condensation than the sun, since, on the hypothesis of equal density, the surface of the larger member is one-third that of the sun, while the intrinsic light is less than one-ninth.

(4.) The companion of Sirius appears to have reached a stage of greater maturity than the sun, while the contrary seems to be true in regard to the principal star. H. A. N.

3. *Annals of the Astronomical Observatory of Harvard College.* Vols. VIII and X.—The first seven volumes of the Annals of the Astronomical Observatory of Harvard College contained the results of the work done under its first two Directors, W. C. Bond and G. P. Bond.

Three catalogues gave the observed places of 16,084 stars observed in zones between the equator and 1° N. declination. The great comet of 1858, the nebula of Orion, and spots on the sun, each filled a volume, and the planet Saturn filled one part of a volume. The second part of vol. IV has not yet appeared, but is in course of publication. The eighth volume contains in its first part an historical account of the Observatory from 1855 to 1876, and is richly illustrated by engravings of the instruments and apparatus of the Observatory. The second portion consists of the "Engravings from the Observatory of Harvard College," which has been furnished separately to subscribers, and has been heretofore noticed in this Journal. They are thirty-five in number (making more than fifty engravings in the volume), and constitute a most valuable contribution to Descriptive Astronomy. The tenth volume of the Annals contains the first portion of the work, with the new Meridian Circle under Prof. Winlock. The observations were made in 1871 and 1872 by Prof. W. A. Rogers, aided by Mr. A. McConnel, and the reduction of them and the editing of the volume was by Prof. Rogers. There were 564 stars observed, mostly bright ones. The introduction contains an elaborate comparison of these observations with the places given for the same stars in twenty-seven earlier catalogues. The volume concludes with three catalogues: 1st, of 289 primary stars, being those which are in the list of fundamental stars of the Astron. Gesellschaft; 2d, of the 275 stars not in that list; 3d, of about 600 stars observed in R. A. in 1867 and 1868, with the transit circle, by Mr. E. P. Austin. H. A. N.

4. *Meteoric Fireballs.*—Professor Kirkwood gives an account of eight large bolides between July, 1876 and February, 1877, to the American Philosophical Society. The more important ones have been noticed in this Journal, except one of July 8th, 1876, at 8^h 45^m P. M., which from an altitude of 88 miles passed N. 78° W. across the N. E. corner of Indiana, and exploded over Lake Michigan at a height of 34 miles. The path was inclined 21° to the horizon; no detonation reported; train visible 40 minutes.

5. *On the part of the motion of the lunar perigee which is a function of the mean motions of the Sun and Moon;* by G. W. Hill. Cambridge, 1877. 4°, pp. 28.—The motion of the lunar perigee as observed does not agree with any of those computed by theory within the limits of error of the observations. This may be due to not carrying the approximations far enough and the author undertakes to compute its value, so far as it depends on the mean motions of the sun and moon, with a degree of accuracy that shall leave nothing further to be desired.

6. *Chicago Observatory.*—Referring to the statement of Mr. Burnham in this number (p. 31) we beg of the friends of science in Chicago to see if it is not possible to secure for him in some way the use of the telescope in the Observatory. For many years this large instrument (for a part of the time the largest refractor in the world) has lain idle, not at all to the credit of Chicago. It should have been steadily doing service in astronomy, such service as almost no other instrument can do. Mr. Burnham has shown that he can do good work, and the friends of science everywhere have a right to complain that the instrument lies idle when he is willing to use it.

7. *The Observatory, a Monthly Review of Astronomy.* Edited by W. H. M. CHRISTIE, M.A. Nos. 1 and 2, April and May.—This is a new monthly of thirty-two pages, published by Taylor & Francis, London. For convenience of American subscribers currency will be received at the rate of one dollar for three months' subscription. These two numbers contain accounts of the April and May meetings of the Royal Astr. Soc.; and the following besides other articles: Photographic Spectra of Stars, by W. Huggins; Determination of the Solar Parallax, by D. Gill; the Twinkling of the Stars, by E. Ledger; also Notes, Correspondence, Memoranda, Ephemerides, &c.

8. *An Elementary Treatise on Elliptic Functions;* by ARTHUR CAYLEY. Deighton, Bell & Co. Cambridge and London. 8°, 1876.—There has been hitherto no elementary separate treatise in English upon elliptic functions. The thanks of mathematicians are due to Professor Cayley for supplying the want. An excellent feature of the book is the *general outline* which fills the first chapter.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association.*—The American Association will hold its twenty-sixth meeting in Nashville, during the week commencing with the 29th of August. The Local Committee is making arrangements for the private entertainment of the members where they may desire it, and also for free return tickets as far as practicable, besides providing, by means of excursions and in other ways, for the pleasure and profit of those who shall be present. The president of the meeting is SIMON NEWCOMB, of Washington, and the vice-presidents, EDWARD C. PICKERING, of Cambridge and O. C. MARSH, of New Haven. Mr. J. Berrien Lindsley is Secretary of the Local Committee.

2. *New American Scientific Museums.*—A bill to establish a Historical Library and Natural History Museum at Springfield, Illinois, has been passed by the Legislature of the State. It appropriates to it one of the large halls of the New Capitol building. The valuable collections made in connection with the geological survey of the State, many specimens of which are the types of new species described in the volumes of Reports, will here have safe

keeping. Professor Worthen writes, that about it will be built up an institution of science that will be an important addition to the educational resources of the West.

At St. Louis, Missouri, the "St. Louis Museum of Arts and Sciences" has recently been instituted. It includes among its officers the names of prominent men of science of Missouri, and promises to be a center of great scientific activity.

3. *Earthquake oceanic wave of May 9th and 10th*, 1877.—The Monthly Weather Review for May, published by the Signal Service under Gen. Albert J. Mayer, contains many details respecting this earthquake wave, and a table of data for estimating approximately the velocity. About 8.50 P. M. of May 9th, heavy earthquake shocks were felt over the region between Arica and Mexillones (border of Peru and Bolivia). The oceanic wave which immediately followed was of great violence along the adjoining South American coast, and was felt also as far north as California, the rise at Anaheim (33° 8'), being 12 feet in a few minutes. The wave at Callao, Peru, was felt at 11 P. M.; at San Francisco, perceptible at 6^h 18' A. M., May 10, and 14 inches in rise (maximum) at 8^h 20'; the Sandwich Islands, on eastern Hawaii, at Hilo, at 4 A. M., and the great wave, 36 feet high, came in at 4^h 45'; at Honolulu, first felt at 4^h 45', and the great wave at 5^h.

Rev. T. Coan, in a letter to one of the editors dated May 11, states that "thirty-six hours subsequent to the catastrophe at Hilo, the pulsations of the tidal wave still continued, the incoming and outflowing wave occupying about an hour, the latter leaving the channels nearly bare."

4. *A practical Treatise on Lightning Protection;* by HENRY W. SPANG. 180 pp. 12°. Philadelphia, 1877. (Claxton, Remsen & Haffelfinger.)—This treatise discusses the various questions that arise in the construction of lightning rods, and their application to different kinds of structures. The great defect of most lightning rods, that of imperfect earth connections, with the remedies, are very fully treated. The directions are such that an intelligent mechanic can carry them into effect.

With many minor statements of the author we should not agree. Thus (p. 176) he says, "a building over 100 feet square cannot be properly protected unless in addition to the conductors and earth-terminals upon the outside thereof, a suitable number of conductors are employed through the interior, etc." The book, however, as a whole, is one to be heartily commended.

5. *Natural Philosophy for Beginners;* Part I, *the Properties of Solid and Fluid Bodies;* by I. TODHUNTER, M.A., F.R.S. 368 pp. small 8vo. London, 1877. (MacMillan & Co.)—The character of this little work will be best understood by the following quotation from the author's preface:—"The design of the work is to furnish a simple and trustworthy manual for those who are beginning the study of natural philosophy; and it ventures to claim a distinct position among the numerous publications

which have appeared with somewhat similar aims. On the one hand great pains have been taken to render the book intelligible to early students; the amount of mathematical knowledge assumed is merely a familiarity with the elements of arithmetic. On the other hand the subject is presented, it may be hoped, with adequate fullness, so that a person who has mastered the work will have gained considerable acquaintance with the principles of natural philosophy. Moreover, a collection of examples for exercise (above 500 in number) is added." The many excellent text-books of Prof. Todhunter are now so well known that it is unnecessary to add more than a general commendation of the manner in which the author's plan, as above expressed, has been carried out. The second part of the work is now in the press.

6. *Third Biennial Report of the Vermont Board of Agriculture, Manufactures and Mining, for the years* 1875–76. By Henry M. Seely, Secretary of the Board. 704 pp. 8vo. Rutland, 1876.—This volume is made up of brief original reports by various citizens of Vermont on topics of general interest connected especially with agriculture, and to some extent with manufactures. Among the interesting chapters there is one on the relation of bees to fruit culture, by J. E. Crane, of Bridport; others —on an analysis of fertilizers, by Prof. Seely; Pisciculture with reference to farming, by G. B. French, of Woodstock; Experiments in the hybridization of cereals, by C. G. Pringle, of Charlotte; Insects injurious to the potato and apple, by Prof. G. H. Perkins.

7. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters.* Vol. III, 1875–76. 270 pp. 8vo. Madison, Wisconsin.—Among the original scientific papers in this volume there are the following: Kaolin in Wisconsin, by R. Irving; on the Geology of Northern Wisconsin, by E. T. Sweet; on some of the small lakes of Wisconsin, by I. A. Lapham; on Copper tools found in Wisconsin, by J. D. Butler; Report of Committee on Exploration of Indian Mounds in the vicinity of Madison.

8. *Journal of the Academy of Natural Sciences of Philadelphia,* Vol. VIII, part 2.—This part contains papers on Batrachia and Reptilia of Costa Rica and elsewhere, by E. D. Cope; on the Ichthyology of Lake Titicaca, by the same; and a descriptive catalogue of the Scalidæ of the West India Islands, by O. A. L. Mörch.

Manchester Science Lectures for the People. Eighth series, 1876–77, in pamphlets of 45 to 64 pages, 12mo.—Why the Earth's Chemistry is as it is; three lectures by J. Norman Lockyer, F.R.S.; 60 pp.—The Succession of Life on the Earth; three lectures by Professor W. C. Williamson, F.R.S.; 62 pp.—Technical Chemistry, by Professor Roscoe, F.R.S., 46 pp. Macmillan & Co., London and New York.

OBITUARY.

Elkanah Billings.—The decease of Mr. Billings a year since, at Montreal, was announced in this Journal, in volume xii, at page 80. We are indebted to his successor as paleontologist in the Canada Geological Survey, Mr. J. F. Whiteaves, for the following facts connected with his labors in science.

Mr. Billings was born near Ottawa City, on the 5th of May, 1820, and died on the 14th of June, 1876. In 1839 he commenced the study of law, and for seven years, beginning with 1844, his pursuit was that of a barrister. For the four years following he added the duties of editor of the "Ottowa Citizen." But between 1852 and 1856 a large proportion of his time was devoted to the collection and study of the Lower Silurian fossils of the country about Ottawa City, and this brought him into familiar correspondence with Sir William Logan, and led to his appointment, in 1856, to the position of paleontologist of the Geological Survey of Canada. He had been elected a member of the Canadian Institute of Toronto in 1854, and published the same year, in its Journal, his first paleontological paper—"On some Genera and Species of Cystidea from the Trenton limestone." In 1856, he commenced the publication of the "Canadian Naturalist and Geologist;" but he was relieved of the responsibility of editor the following year by a committee of the Natural History Society of Montreal, while continuing to be a large contributor to its pages. With the exception of part of the year 1858, which was spent in Great Britain and Paris, studying and comparing such foreign and North American British fossils as threw light on Canadian species, the remainder of his life was passed at Montreal, in the study of the Canadian collections, and in excursions among the fossiliferous rocks of Canada and adjoining portions of the United States. Besides numerous papers contributed to the Canadian Journal of Toronto, the Canadian Naturalist of Montreal, the Geological Magazine, and to the pages of this Journal, he published the following more extended memoirs: An illustrated monograph of Lower Silurian Cystidea and Asteriadæ, and on the Crinoidea of the same formation: these two memoirs constituting Decades 3 and 4 of "Canadian Organic Remains;" Palæozoic Fossils, vol. i, 526 pp. 8vo, with numerous figures, 1865, and vol. ii, part 1, 144 pp. 8vo, with nine plates and many wood-cuts, 1874; and "Catalogues of the Silurian Fossils of the Island of Anticosti."

Mr. Billings's knowledge of the invertebrates of the Silurian and Devonian formations was extensive and profound, and his descriptions of fossils are both lucid and scrupulously accurate. To his critical acumen we are indebted for a very considerable part of our knowledge of American paleontology; and especially for his elaboration of the remarkable, and still somewhat enigmatical, fauna of the Quebec Group, of the south shore of the St. Lawrence, in Eastern Canada, and of the northern extremity of Newfoundland. His paper "on the remains of the Fossil Elephant found in Canada,"* and another on the bones of a Beluga dug up at Cornwall (Ontario),† show that he was well versed in comparative osteology, and many of his earlier contributions to the "Canadian Naturalist" bear witness to the eagerness with which he prosecuted his zoological studies. Entomology and mineralogy were favorite departments of science with him, and he made at one time a tolerably complete collection of Canadian Coleoptera, which he presented to the Natural History Society of Montreal a few years before his death.

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* Canadian Naturalist, First Series, vol. viii, 1863.

† Read before the Natural History Society of Montreal, but never published.

For many years Mr. Billings was one of the Vice-Presidents of the Natural History Society of Montreal. He was frequently pressed to accept the office of President, but invariably declined. He was elected a Fellow of the Geological Society of London in 1858. The silver medal of the Montreal Natural History Society was voted him by the members at the annual meeting held in 1867, by way of testifying to their appreciation of "his long continued and successful labors for the promotion of science in Canada."

Mr. Billings possessed great firmness and strength of character coupled with a winning simplicity of manner and unaffected modesty. To these traits were added inflexible love of truth and justice, disinterested and self-sacrificing zeal for the acquisition of knowledge, and untiring industry in his pursuits.

In 1845 Mr. Billings married a sister of Mr. Wilson, of Toronto, now the Hon. Judge Wilson, but then the junior partner in the legal firm of Messrs. Baldwin & Wilson, in whose office he studied the last year prior to his being called to the bar. Since his decease the members of the Natural History Society of Montreal have passed resolutions expressing their high estimation of his personal character and writings; and a few of his more intimate friends in the society have subscribed for a fine life-sized portrait of their distinguished associate, which now adorns its lecture room.

Colonel Ezekiel Jewett, died at Santa Barbara, Cal., May 18th, aged 86. He was born at Rindge, N. H., Oct. 16, 1791. He was an officer in the U. S. army in the war of 1812, and afterward took part in the Chilian war, under Gen. Carrera. He has long been well known to geologists and conchologists as an enthusiastic and indefatigable collector of fossils and shells. An extensive geological collection, made by him, is now the property of Cornell University. For several years past he has devoted himself entirely to conchology and had accumulated a valuable collection of shells, embracing over 12,000 species. He collected extensively on the west coast of Florida.

Dr. Philip P. Carpenter, one of the ablest modern conchologists, well known especially for his several excellent works on the mollusca of the west coast of North America, died at Montreal, May 24th, aged fifty-eight. A more extended notice is necessarily deferred to another number.

Robert Dale Owen, died on the 24th of June, at his summer residence on Lake George, at the age of seventy-six.

APPENDIX.

ART. XI. — *Principal Characters of the Coryphodontidæ;* by Professor O. C. MARSH. With plate IV.

NEAR the base of the Eocene, in the Rocky Mountain region, are numerous remains of a well marked group of mammals which the writer has termed the *Coryphodontidæ*.* These animals are of peculiar interest, both on account of their structure and affinities, and especially as they are among the oldest of Tertiary Mammals, and mark a definite geological horizon in this country and Europe. Only the single genus, *Coryphodon*, is known, and this was established, in 1846, by Owen, who described a characteristic fragment of a lower jaw from the London Clay of England.† Other imperfect specimens were subsequently found in France, and fully described by Hébert,‡ but up to the present time very little is known of this genus from European specimens.

The identification of the American remains with the genus *Coryphodon* of Owen, and the determination thereby of a definite horizon, common to the two countries, and containing the oldest known Tertiary Mammals, was published by the writer in April, 1876, and subsequently in the following number of this Journal (vol. xi, p. 425.)§

The Museum of Yale College contains a large collection of *Coryphodon* remains from Utah, Wyoming, and New Mexico, and this material is amply sufficient to indicate all the more important characters of the group. Among these specimens are portions of the same individuals described by Cope under the names *Bathmodon* and *Loxolophodon*,‖ both of which are synonyms of *Coryphodon*, as the remains on which they were based clearly belong to that genus. One of the species best represented in the Yale collection is *Coryphodon hamatus* Marsh, and this has afforded many of the characters given below.

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* This Journal, vol. xi, p. 428, May, 1876.

† British Fossil Mammals and Birds, p. 299.

‡ Annales des Sciences Naturelles, tome vi, p. 87, 1856.

§ In the American Naturalist (vol. xi, p. 95), Prof. Cope has recently claimed this discovery on the strength of a paper which he read before the Spring Meeting of the National Academy, in 1876. He knew, however, at the time that my article was already published, and during the reading of his paper, a printed copy of my publication was in the room, in the hands of a member.

‖ Proceedings American Philosophical Society, 1872, p. 420.

The skull of *Coryphodon*, in all its more important characters, is of the perissodactyl type. It is elongated, and the facial portion is most produced. A line drawn from the lower margin of the foramen magnum along the palate is nearly straight. The zygomatic arches are expanded, but the malar is comparatively slender, and unites with the maxillary in front of the orbit. The general form of the skull is shown in the accompanying plate, figure 1. The maxillaries are massive, and usually deeply indented on the sides behind the canines. The lachrymal forms the anterior border of the orbit, and its foramen is inside the orbital margin. The nasals are slender in front, and broad posteriorly. The premaxillaries are expanded transversely, and the narial aperture is wide. The occipital condyles are well separated, and there are condylar foramina. Between the basisphenoid and the periotic, there is a large opening. There is a paroccipital, and a post-glenoid process.

The dental formula of *Coryphodon* is as follows:

$$\text{Incisors } \frac{3}{3}; \text{ canines } \frac{1}{1}; \text{ premolars } \frac{4}{4}; \text{ molars } \frac{3}{3}; \times 2 = 44.$$

The teeth in American specimens do not differ essentially from those described by Owen and Hébert, which are well represented in the memoir of the latter author, cited above.

The brain cavity in *Coryphodon* is perhaps the most remarkable feature in the genus, and indicates that the brain itself was of a very inferior type. It was quite small, as in all Eocene mammals, but its most striking features were the small size of the hemispheres, and the expanded cerebellum. The form and relative size of these are shown in the accompanying plate, figure 1.

The olfactory lobes were large, and entirely in advance of the hemispheres. They were bounded in front by a well ossified cribriform plate, and partially separated by a vertical bony septum. The cerebral lobes were ovate in form, and very small, a transverse section exceeding but little that of the medullar opening. In shape and relative size, the hemispheres and olfactory lobes of this genus are somewhat similar to those of *Dinoceras.* The cerebellum was proportionally large, and widely expanded transversely. Its peculiar form is shown in figure 1, which is drawn from a cast of the brain-cavity of *C. hamatus.* This portion of the brain nearly or quite equaled the hemispheres in size, thus differing widely from any known mammal. There is a well marked pituitary fossa, but no clinoid process. The foramina for the exit of the optic nerves are small, but for the others very large. The brain as a whole was very low in grade, and precisely such as might be expected in a mammal from the oldest Tertiary deposits.

These essential characters of the brain of *Coryphodon* were determined and published by the writer more than a year ago, with figures of a very perfect cast of the brain-cavity. (This Journal, vol. xi, p. 427.) Two skulls, in remarkable preservation, were examined during the investigation, and the results have since been confirmed by other specimens in the Yale Museum.

These facts are important, since Cope has recently published a paper on the same subject, and given descriptions and figures of the brain case of *Coryphodon* which differ materially from my own.* He makes no reference to my article, although perfectly familiar with it. A comparison of his figures with the specimens mentioned above, shows at once that he has made most serious mistakes in his observations. What he represents as olfactory lobes, are unlike anything in nature, and are merely a cast from an imperfect skull in which the mesethmoid septum, and the cribriform plate are both evidently imperfect or wanting. Similar errors are apparent in other portions of the figures, and his classification, based on these and like observations, is untenable, as the known facts are against it.

The vertebræ of *Coryphodon*, in their more important characters, resemble those of *Dinoceras*. The cervicals are proportionately longer. The odontoid process of the axis is a short peg. The articular faces of the cervicals and dorsals are nearly flat. The caudals indicate a tail of moderate length.

The limbs of *Coryphodon* were comparatively short. The scapula is acuminate above, as in *Dinoceras* and the Elephant. The humerus is much less massive than in *Dinoceras*, but otherwise resembles it. The deltoid ridge extends beyond the middle of the shaft. The distal end of the humerus is compressed antero-posteriorly, and the ulnar side of the articulation is much more prominent than the radial, thus approaching the Rhinoceros where it departs from *Dinoceras*. The radius is proximally smaller, compared with the ulna, than in Rhinoceros. Its distal end is larger than that of the ulna.

The femur of *Coryphodon* is of the perissodactyl type, and has a distinct third trochanter. The tibia, when in position, was not in the same line with the femur, as in *Dinoceras* and the Elephant, but was inclined at a moderate angle. The fibula was entire, and its distal end articulated with both the astragalus and calcaneum.

The feet of *Coryphodon*, hitherto essentially unknown, resemble most nearly those of *Dinoceras*, and can perhaps be best illustrated by a direct comparision with them. In the following figures (see plate iv), the feet of these two genera are placed side by side, and in the same position. The main points of difference between them are stated below.

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* Proceedings American Philosophical Society, p. 616, 1877.

The manus and pes of *Coryphodon* had each five short digits. The carpal bones are shorter, measured in the line of the foot, than in *Dinoceras*, and the distal row present more curved articular faces to the metacarpal bones, indicating greater freedom of motion. The pyramidal is destitute of the tubercle projecting outward and forward for the support of the fifth digit, seen in *Dinoceras*. The metapodial bones and phalanges are throughout less roughened and tubercular than in *Dinoceras*, and all their articular faces indicate greater flexibility in the feet. The ungual phalanges expand laterally for the support of the hoofs, instead of being rounded, as in *Dinoceras*.

In the hind foot, the astragalus, and in a less degree the cuboid and navicular bones are shorter, along the line of the foot, than the corresponding bones of *Dinoceras*. The astragalus has the tibial articulation less convex, and the fibular articulation more extensive, covering the whole exterior or fibular side of the bone. The navicular and cuboid faces are more distinctly separated, and make a greater angle with each other than in *Dinoceras*. The calcaneum approaches the ordinary perissodactyl type, the shaft being much longer than in *Dinoceras*, and the tubercular surface below for the support of a plantar pad, seen in the Elephant and *Dinoceras*, is undeveloped. The cuboid is of peculiar shape, being sub-triangular. The calcaneal face is long and oblique, reaching nearly to the face for the fifth metatarsal. Both the metatarsal articulations are essentially in one plane, and are separated only by a very slight ridge. The navicular articulates very slightly, if at all, with the cuboid, but covers the face of the astragalus, and fully supports the ectocuneiform. The latter bone is not at all supported by the astragalus, as asserted by Cope (Catalogue of Vertebrata of the Eocene of New Mexico, p. 27). He has also published a remarkable figure of the hind foot of *Coryphodon* (Bathmodon), showing the hallux with three phalanges, and the fifth digit reduced to a rudiment (loc. cit., p. 28).

The average size of the animals of this genus was about that of the existing Tapir. Some were smaller, and others nearly twice as large. Their mode of life was probably similar.

A careful consideration of the characters of *Coryphodon*, so far as now known, indicates that the genus represents a distinct family of perissodactyl Ungulates, the *Coryphodontidæ*. The skull is clearly of this type, and the skeleton and feet present no differences sufficiently important to justify a separation from that natural order. Only a slight modification of the limits of the *Perissodactyla*, would bring this five-toed genus into it, and simplify classification.

The geological horizon of *Coryphodon* in this country is near the base of the Eocene, in the strata named by the Survey of the Fortieth Parallel, under Clarence King, the Vermillion Creek series, and by Hayden the Wasatch group. The known localities are in Utah, Wyoming and New Mexico. Among the associate mammals are the equine *Eohippus*, and the suilline *Helohyus*, showing clearly that we must look to Cretaceous strata at least for the parent form of the Ungulates.

Yale College, June 12th, 1877.

ART. XII.—*Characters of the Odontornithes, with Notice of a new allied Genus;* by Professor O. C. MARSH. With plate V.

THE Cretaceous birds with teeth, (*Odontornithes*), described by the writer, prove on careful investigation to possess some important characters in addition to those already published.* This is especially true of *Hesperornis*, which is now represented in the Yale College Museum by so large a number of specimens that almost every part of the skeleton is known, and all the more important points in its structure have been determined.

The most marked features in this genus already announced, are: the teeth in grooves; sternum without keel, and rudimentary wings; and posterior limbs closely resembling those of modern diving birds. The last character, which seemed at first sight to indicate the near affinity of *Hesperornis* with the *Colymbidæ*, proves to be only an adaptation; while the skull, scapular arch, and other important portions show unmistakably that the nearest existing allies of the genus are the *Ratitæ*, or Ostrich group, the most reptilian of modern birds. The characters that show this affinity are nearly identical with those laid down to distinguish the *Ratitæ* by Huxley in his important memoir on the Classification of Birds.† They may be briefly stated as follows:

1. The sternum is devoid of a crest.
2. The long axes of the adjacent parts of the scapula and coracoid are parallel, or identical.
3. The posterior ends of the palatines, and the anterior ends of the pterygoid are very imperfectly, or not at all, articulated with the basisphenoid rostrum.
4. Strong "basipterygoid" processes, arising from the body of the basisphenoid, and not from the rostrum, articulate with facets which are situated nearer the posterior than the anterior ends of the inner edges of the pterygoid bones.
5. The upper, or proximal, articular head of the quadrate bone is not divided into two distinct facets.

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* This Journal. vol. x, p. 403, Nov., 1875.

† Proceedings Zoological Society, 1867, p. 448.

The vomers are separate, as in lizards and a few modern birds. In the pelvic arch, the ilium, ischium and pubis are free at their distal ends, as in the Emu, and the acetabulum is perforated only by a moderate foramen.

The scapular arch of *Hesperornis* is represented in plate V, figure 1. Its position in the skeleton is shown in the restoration, figure 2.

The scapula is long and slender, and has no acromial process. The clavicles are separate, but meet on the median line, as in some very young existing birds. The coracoids are short, and much expanded where they join the sternum. The latter has no distinct manubrium, and is entirely without a keel. The wings were represented by the humerus only, which is long and slender, and without any trace of articulation at its distal end. Its position was close to the ribs, and it was probably nearly or quite concealed beneath the integuments, as in *Apteryx*. This rendered the rudimentary wings of no possible service in flight or swimming.

***Baptornis advenus*, gen. et sp. nov.**

The existence of a small swimming bird cotemporary with *Hesperornis* is indicated by a nearly perfect tarso-metatarsal bone from the same geological horizon. This specimen, although pertaining to a bird not fully adult, is in excellent preservation, and is so characteristic that it may be readily distinguished from any forms already described.

In general shape and proportions, this bone most nearly resembles the corresponding part in *Hesperornis*, but differs from it decidedly in the outer metatarsal, which at its lower end scarcely equals the adjoining one in size and length. In *Hesperornis*, on the contrary, the outer metatarsal is more than double the size of the third. In the present specimen, the three trochlear articulations of the distal ends are nearly equal. The existence of a hallux is indicated by a small elongated depression on the inner metatarsal, a short distance above the articulation. As in *Hesperornis*, there are no canals or grooves for tendons on the posterior face of the proximal end.

The principal dimensions of this tarso-metatarsal are as follows:—

Entire length	**76·mm**
Transverse diameter of proximal end	**17·**
Antero-posterior diameter	**8·**
Length of second metatarsal	**64·5**
Length of third metatarsal	**72·**
Length of fourth metatarsal	**72·**
Antero-posterior diameter of distal articulation of second metatarsal	**8·5**

Transverse diameter	5· mm
Antero-posterior diameter of distal articulation of third metatarsal	9·2
Transverse diameter	6·
Antero-posterior diameter of distal articulation of fourth metatarsal	9·
Transverse diameter	5·5

This specimen indicates a bird about as large as a loon, and apparently of similar habits. The locality of the only remains at present known is in Western Kansas, in the same Cretaceous beds that contain the *Odontornithes* and *Pteranodontia.*

Art. XIII.—*Notice of a new and Gigantic Dinosaur;* by Professor O. C. Marsh.

The Museum of Yale College has recently received from the Cretaceous deposits of Colorado a collection of reptilian remains of much interest. Among these specimens are portions of an enormous Dinosaur, which surpassed in magnitude any land animal hitherto discovered. The most characteristic bones preserved are portions of the sacrum, and posterior limbs. The former is represented by the last two vertebræ with their transverse processes, nearly complete, and by other fragments. The last sacral vertebra has its centrum moderately concave below on each side of the median line, but only near its anterior end can indications of a keel be observed. The next sacral vertebra has its inferior lateral surface so deeply concave as to materially lessen its bulk. This is also true of the next anterior centrum, and may be considered a distinctive character of these vertebræ. A more important character of the same centra is a very large cavity in each side, connected with the outer surface by an elongated foramen, below the base of the neural arch. The inner surface of this cavity indicates that it was not filled by cartilage, and it probably was a pneumatic opening, designed to lessen the weight of the enormous sacral mass. The transverse processes of these vertebræ are very stout, and of moderate length. Their distal ends are firmly coössified, forming a powerful support for the ilium. Between these processes are large oval openings.

The following measurements give the more important dimensions of these interesting fossils:

Length of centrum of last sacral vertebra	300· mm
Transverse diameter of distal end	270·
Vertical diameter of distal end	250·
Distance between extremities of transverse processes	850·

Length (approximate) of next sacral vertebra	280· mm
Transverse diameter of posterior end	200·
Least transverse diameter of centrum	85·
Distance between extremities of transverse processes	680·
Antero-posterior diameter of opening between transverse processes of above vertebræ	150·
Tranverse diameter	115·
Antero-posterior diameter (approximate) of shaft of femur	230·
Transverse diameter	350·

These dimensions would indicate for the entire animal a length of probably fifty to sixty feet. It was apparently an herbivorous reptile, and as it is quite distinct from any hitherto described, the species may be called *Titanosaurus montanus.* It was perhaps a distant ally of the comparatively small *Hadrosaurus agilis* Marsh, the only Dinosaur hitherto found in the Cretaceous of Kansas.

With the remains here described were found portions of a much smaller carnivorous reptile of the same order, which apparently belongs to the genus named by Cope *Lælaps.*[*] These remains, with those already noticed, will soon be more fully described by the writer. Their locality is in the Dakota group of Colorado, on the eastern flanks of the Rocky Mountains, where they were discovered by Professor Arthur Lakes and Captain H. C. Beckwith, U. S. N.

Yale College, New Haven, June 20th, 1877.

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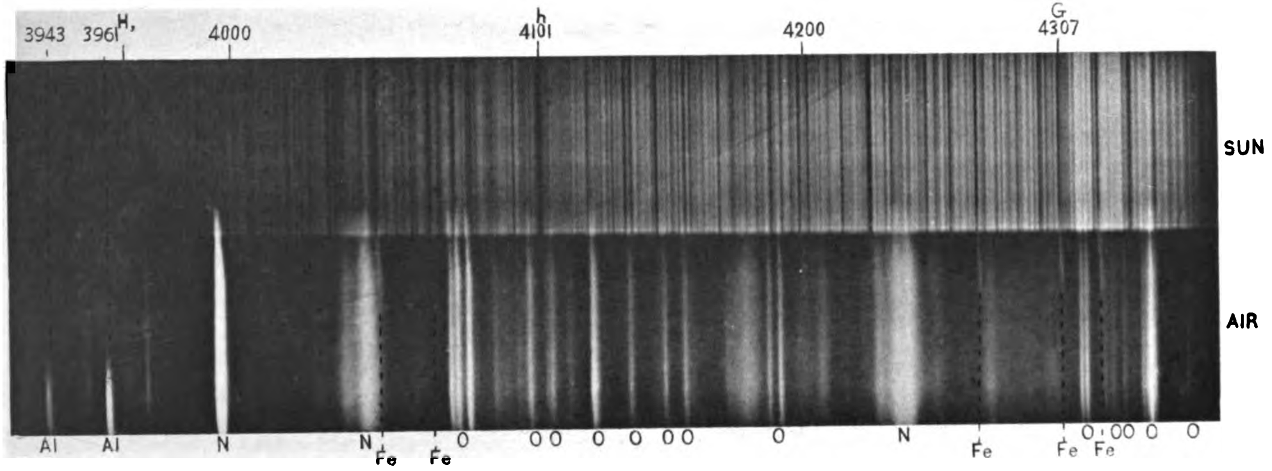
[*] This name *Lælaps* is preoccupied, having been used by Koch in 1836, and again by Walker in 1843. It may, therefore, be replaced by *Dryptosaurus.* This genus is allied to *Megalosaurus*, and is represented in American Cretaceous strata by several species, among them *Dryptosaurus aquilunguis.*



DISCOVERY OF OXYGEN IN THE SUN BY PHOTOGRAPHY, BY PROFESSOR HENRY DRAPER. M. D, 1870.

The upper part of the photograph is the spectrum of the Sun, the lower part is the spectrum of the Oxygen and Nitrogen of Air. The letters and figures on the margin are printed with type on the negative; with this exception the photograph is absolutely free from hand work or retouching. O. indicates Oxygen, N. Nitrogen, Fe. Iron, Al. Aluminium. The figures above the Sun's spectrum are wave-lengths; G. h, H., are prominent Solar lines at the violet end of the spectrum. The principal point to examine is the coincidence of the bright Oxygen lines with bright lines in the Solar spectrum. The picture is printed from Draper's original negative by Bierstadt's Albertype process.

THE

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[THIRD SERIES.]

ART. XIV.—*Discovery of Oxygen in the Sun by Photography, and a new Theory of the Solar Spectrum*;* by Professor HENRY DRAPER, M.D.

I PROPOSE in this preliminary paper to indicate the means by which I have discovered oxygen and probably nitrogen in the sun, and also to present a new view of the constitution of the solar spectrum.

Oxygen discloses itself by bright lines or bands in the solar spectrum, and does not give dark absorption lines like the metals. We must therefore change our theory of the solar spectrum and no longer regard it merely as a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapors, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, etc., but also may account for some of the so-called dark lines by regarding them as intervals between bright lines.

It must be distinctly understood that in speaking of the solar spectrum here, I do not mean the spectrum of any limited area upon the disc or margin of the sun, but the spectrum of light from the whole disc. I have not used an image of the sun upon the slit of the spectrocope, but have employed the beam reflected from the flat mirror of the heliostat without any condenser.

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* Read before the American Philosophical Society, July 20th, 1877.

In support of the above assertions the accompanying photograph of the solar spectrum with a comparison spectrum of air, and also with some of the lines of iron and aluminium, is introduced. The photograph itself is absolutely free from handwork or retouching. It is difficult to bring out in a single photograph the best points of these various substances, and I have therefore selected from the collection of original negatives that one which shows the oxygen coincidences most plainly. There are so many variables among the conditions which conspire for the production of a spectrum, that many photographs must be taken to exhaust the best combinations. The pressure of the gas, the strength of the original current, the number of Leyden jars, the separation and nature of the terminals, the number of sparks per minute and the duration of the interruption in each spark, are examples of these variables.

In the photograph the upper spectrum is that of the sun and above it are the wave-lengths of some of the lines to serve as reference numbers. The wave-lengths used in this paper have been taken partly from Angström and partly from my photograph of the diffraction spectrum published in 1872. The lower spectrum is that of the open air Leyden spark, the terminals being one of iron and the other of aluminium. I have photographed oxygen, nitrogen, hydrogen and carbonic acid as well as other gases in Plücker's tubes, and also in an apparatus in which the pressure could be varied, but for the present illustration the open air spark was, all things considered, best. By other arrangements the nitrogen lines can readily be made as sharp as the oxygen are here, and the iron lines may be increased in number and distinctness. For the metals the electric arc gives the best photographic results as Lockyer has so well shown, but as my object was only to prove by the iron lines that the spectra had not shifted laterally past one another, those that are here shown at 4325, 4307, 4271, 4063, 4045, suffice. In the original collodion negative many more can be seen. Below the lower spectrum are the symbols for oxygen, nitrogen, iron and aluminium.

No close observation is needed to demonstrate to even the most casual observer, that the oxygen lines are found in the sun as bright lines, while the iron lines have dark representatives. The bright iron line at G (4307), on account of the intentional overlapping of the two spectra can be seen passing up into the dark absorption line in the sun. At the same time the quadruple oxygen line between 4345 and 4350 coincides exactly with the bright group in the solar spectrum above. This oxygen group alone is almost sufficient to prove the presence of oxygen in the sun, for not only does each of the four components have a representative in the solar spectrum, but the relative strength and the general aspect of the lines in each case is similar. I do not think that in comparisons of the spectra of the elements and sun, enough stress has been laid on the general appearance of lines apart from their mere position; in photographic representations this point is very prominent. The fine double line at 4319, 4317, is plainly represented in the sun. Again there is a remarkable coincidence in the double line at 4190, 4184. The line at 4133 is very distinctly marked. The strongest oxygen line is the triple one at 4076, 4072, 4069, and here again a fine coincidence is seen though the air spectrum seems proportionately stronger than the solar. But it must be remembered that the solar spectrum has suffered from the transmission through our atmosphere, and this effect is plainest in the absorption at the ultra-violet and violet regions of the spectrum. From some experiments I made in the summer of 1873, it appeared that this local absorption is so great when a maximum thickness of air intervenes, that the exposure necessary to obtain the ultra-violet spectrum at sunset was two hundred times as long as at mid-day. I was at that time seeking for atmospheric lines above H, like those at the red end of the spectrum, but it turned out that the absorptive action at the more refrangible end is a progressive enfeebling as if a wedge of neutral tinted glass were being drawn lengthwise along the spectrum toward the less refrangible end.

I shall not attempt at this time to give a complete list of the oxygen lines with their wave-lengths accurately determined, and it will be noticed that some lines in the air spectrum which have bright analogues in the sun are not marked with the symbol of oxygen. This is because there has not yet been an opportunity to make the necessary detailed comparisons. In order to be certain that a line belongs to oxygen, I have compared, under various pressures, the spectra of air, oxygen, nitrogen, carbonic acid, carburetted hydrogen, hydrogen, and cyanogen. When these gases were in Plücker's tubes a double series of photographs has been needed, one set taken with and the other without Leyden jars.

As to the spectrum of nitrogen and the existence of this element in the sun there is not yet certainty. Nevertheless even by comparing the diffused nitrogen lines of this particular photograph, in which nitrogen has been sacrificed to get the best effect for oxygen, the character of the evidence appears. The triple band between 4240, 4227, if traced upward into the sun has approximate representatives. Again at 4041, the same thing is seen, the solar bright line being especially marked. In another photograph the heavy line at 3995, which in this picture is opposite an insufficiently exposed part of the solar spectrum shows a comparison band in the sun.

The reason I did not use air in an exhausted Plücker's tube for the production of a photograph to illustrate this paper, and thus get both oxygen and nitrogen lines well defined at the same time, was partly because a brighter light can be obtained with the open air spark on account of the stronger current that can be used. This permits the slit to be more closed and of course gives a sharper picture. Besides the open air spark enabled me to employ an iron terminal and thus avoid any error arising from accidental displacement of the reference spectrum. In Plücker's tubes with a Leyden spark the nitrogen lines are as plain as those of oxygen here. As far as I have seen oxygen does not exhibit the change in the character of its lines that is so remarkable in hydrogen under the influence of pressure as shown by Frankland and Lockyer.

The bright lines of oxygen in the spectrum of the solar disc have not been hitherto perceived probably from the fact that in eye-observations bright lines on a less bright background do not make the impression on the mind that dark lines do. When attention is called to their presence they are readily enough seen even without the aid of a reference spectrum. The photograph, however, brings them into greater prominence. From purely theoretical considerations derived from terrestrial chemistry and the nebular hypothesis, the presence of oxygen in the sun might have been strongly suspected, for this element is currently stated to form eight-ninths of the water of the globe, one-third of the crust of the earth and one-fifth of the air and should therefore probably be a large constituent of every member of solar system. On the other hand the discovery of oxygen and probably other non-metals in the sun gives increased strength to the nebular hypothesis, because to many persons the absence of this important group has presented a considerable difficulty.

At first sight it seems rather difficult to believe that an ignited gas in the solar envelope should not be indicated by dark lines in the solar spectrum, and should appear not to act under the law, "a gas when ignited absorbs rays of the same refrangibility as those it emits." But in fact the substances hitherto investigated in the sun are really metallic vapors, hydrogen probably coming under that rule. The non-metals obviously may behave differently. It is easy to speculate on the causes of such behavior, and it may be suggested that the reason of the non-appearance of a dark line may be, that the intensity of the light from a great thickness of ignited oxygen overpowers the effect of the photosphere, just as if a person were to look at a candle flame through a yard thickness of ignited sodium vapor, he would only see bright sodium lines and no dark absorption lines. Of course such an explanation would necessitate the hypothesis that ignited gases, such as oxygen, give forth a relatively large proportion of the solar light. In the outburst of T *Coronæ*, Huggins showed that hydrogen could give bright lines on a background of spectrum analogous to that of the sun.

However all that may be, I have no doubt of the existence of substances, other than oxygen, in the sun, which are only indicated by bright lines. Attention may be called to the bright bands near G, from wave-length 4307 to 4337, which are only partly accounted for by oxygen. Further investigation in the direction I have thus far pursued will lead to the discovery of other elements in the sun, but it is not proper to conceal the principle on which such researches are to be conducted for the sake of personal advantage. It is also probable that this research may furnish the key to the enigma of the D_3 or helium line and the 1474 K or corona line. The case of the D_3 line strengthens the argument in favor of the apparent exemption of certain substances from the common law of the relation of emission and absorption, for while there can be no doubt of the existence of an ignited gas in the chromosphere giving this line, there is no corresponding dark line in the spectrum of the solar disc.

In thus extending the number of elements found in the sun we also increase the field of inquiry as to the phenomena of dissociation and recomposition. Oxygen especially, from its relation to the metals, may readily form compounds in the upper regions of the solar atmosphere which can give banded or channelled spectra. This subject requires careful investigation. The diffused and reflected light of the outer corona could be caused by such bodies cooled below the self-luminous point.

This research has proved to be more tedious and difficult than would be supposed, because so many conditions must conspire to produce a good photograph. There must be a uniform prime moving engine of two horse power, a dynamo-electric machine thoroughly adjusted, a large Ruhmkorff coil with its Foucault break in the best order, a battery of Leyden jars carefully proportioned to the Plücker's tube in use, a heliostat which of course involves clear sunshine, an optical train of slit, prisms, lenses and camera well focussed, and in addition to all this a photographic laboratory in such complete condition that wet sensitive plates can be prepared, which will bear an exposure of fifteen minutes and a prolonged development. It has been difficult to keep the Plücker's tubes in order; often before the first exposure of a tube was over the tube was ruined by the strong Leyden sparks. Moreover to procure tubes of known contents is troublesome. For example, my hydrogen tubes gave a spectrum photograph of fifteen lines, of which only three belonged to hydrogen. In order to be sure that none of these were new hydrogen lines it was necessary to try tubes of various makers, to prepare pure hydrogen and employ that, to examine the spectrum of water, and finally to resort to comparison with the sun.

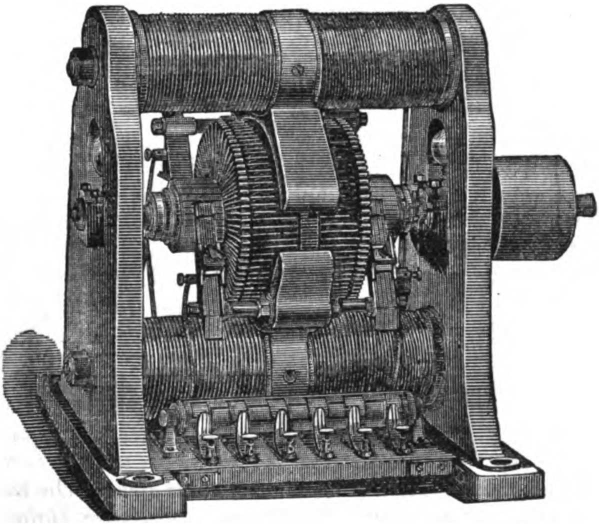
The object in view, in 1873, at the commencement of this research, was to secure the means of interpreting the photographs of the spectra of stars and other heavenly bodies, obtained with my 28-inch reflector. It soon appeared that the spectra of nitrogen and other gases in Plücker's tubes could be photographed, and at first some pictures of hydrogen, carbonic acid and nitrogen were made, because these gases seemed to be of greatest astronomical importance on account of their relation to stars, nebulæ and comets. Before the subject of comparison spectra of the sun was carefully examined, there was some confusion in the results, but by using hydrogen the source of these errors was found out.

But in attempting to make a prolonged research in this direction it soon appeared that it was essential to be able to control the electrical current with precision, both as to quantity and intensity, and, moreover, to have currents which when once adjusted would remain constant for hours together. These conditions are almost impossible to attain with any form of battery, but on the contrary are readily satisfied by dynamo-electric machines. Accordingly I sought for a suitable dynamo-electric machine and motor to drive it, and after many delays procured a combination which is entirely satisfactory. I must here acknowledge my obligations for the successful issue of this search to Professor Geo. F. Barker, who was the first person in America to procure a Gramme machine. He was also the first to use a Brayton engine to drive a Gramme.

The dynamo-electric machine selected is one of Gramme's patent made in Paris and is a double light machine, that is, it has two sets of brushes, and is wound with wire of such a size as to give a current of sufficient intensity for my purposes. It is nominally a 350 candle-light machine, but the current varies in proportion to the rate of rotation, and I have also modified it by changing the interior connections. The machine can produce as a maximum a light equal to 500 standard candles, or by slowing the rotation of the bobbin the current may be made as feeble as that of the weakest battery. In practical use it is sometimes doing the work of more than fifty large Grove nitric acid cells and sometimes the work of a single Smee.

The Gramme machine could not be used to work an induction coil when it first reached me, because when the whole current was sent through the Foucault interruptor of the Ruhmkorff coil, making 1,000 breaks per minute, the electro-magnets of the Gramme did not become sufficiently magnetized to give an appreciable current. But by dividing the current so that one pair of the metallic brushes, which collect from the revolving bobbin, supplied the electro-magnets, the other pair could be used for exterior work, no matter whether interrupted or constant. The current obtained in this way from one pair of brushes when the Gramme bobbin is making 1,200 revolutions per minute, is equal to one hundred candles, and is greater in quantity and intensity than one would like to send through a valuable induction coil. I usually run the bobbin at 622 revolutions per minute, and this rate will readily give 1,000 ten-inch sparks per minute with the eighteen-inch coil. Of course a Plücker's tube lights up very vividly, and generally, in order to get the maximum effect, I arrange the current so that the aluminium terminals are on the point of melting. The glass, particularly in the capillary part, often gets so hot as to char paper. The general appearance of the machine is shown in fig. 1.

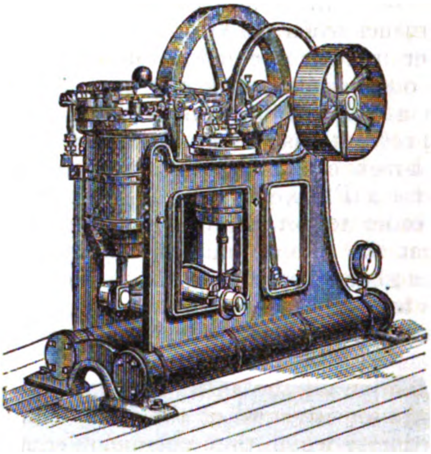
1.



The Gramme Machine.

As long as the Gramme bobbin is driven at a steady rate the current seems to be perfectly constant, but variations of speed make marked differences in the current, and this is especially to be avoided when one is so near the limit of endurance of Plücker's tubes. A reliable and constant motor is therefore of prime importance for these purposes. A difference of one per cent in the speed of the engine sometimes cannot be tolerated, and yet at another time one must have the power of increasing and diminishing through wide limits. The only motor, among many I have examined and tried, that is perfectly satisfactory, is Brayton's Petroleum Ready Motor. This remarkable and admirable engine acts like an instrument of precision. It can be started with a match, and comes to its regular speed in less than a minute; it preserves its rate entirely unchanged for hours together. Moreover, it is economical, cleanly and not more noisy than a steam engine. The one of two horse power I have ran for six months, day and night, supplying water and air to the aquaria in the Centennial Exhibition at Philadelphia. At any time on going into the laboratory it can be started in a few seconds, even though it has not been running for days.

2.



Brayton's Petroleum Motor.

Henry Draper's Observatory, Hastings-on-Hudson, New York.

Art. XV.—*On the Theory of the Action of certain Organic Substances, in increasing the Sensitiveness of Silver Haloids;* by M. C. Lea.

In the early days of photo-chemistry, it was observed that all the silver haloids gained in sensitiveness by being in contact with a soluble silver salt; that when the soluble silver salt was removed by careful washing, a considerable diminution in sensitiveness followed. After a time it was noticed that certain organic substances placed in contact with the washed haloid, appeared to take, to some extent, the place of the silver salt removed, and that the silver haloid was distinctly more sensitive when in contact, for example, with tannin, than when isolated.

In explanation of the fact, a theory was published by M. Poitevin that these organic substances acted in virtue of their affinity for the halogen. That in the case, for example, of tannin and silver iodide, the iodide was more readily attacked by light in the presence of tannin, because the affinity of tannin for iodine came into play in aid of the action of light. Shortly after, Dr. H. Vogel published the same theory.

It is a little remarkable that neither of the authors of this theory, or rather hypothesis, has at any time thought it necessary to support it by experiment or proof of any kind, but both have continued up to the present time to treat the theory as self-evident. In endeavoring to show that this explanation of the reaction cannot be received, I shall have no argument on the other side to combat, or experiments to discuss, as I can find none. I shall, therefore, state what I conceive to be the true explanation, and endeavor to support it adequately by proof.

When we examine all the substances known to be capable of increasing the sensitiveness of the silver haloids, we notice that the one property which they possess in common is, *not* an affinity for the halogen, as the Poitevin–Vogel theory would lead us to expect, but that they *are all reducing agents.* The natural view, therefore, of their action on a silver haloid is, not that they abstract the halogen from it, but that their affinity for oxygen comes into aid of the affinity of the halogen for hydrogen, and that under the influence of light, an atom of water is decomposed. That in the case of silver iodide and tannin, for example, the tannin is oxidized, the iodine is converted into hydriodic acid, and the silver salt is more or less completely reduced, probably to subiodide. According to this view, when silver iodide is exposed to light in presence of an organic body capable of accelerating the action of light, there should be traces of free acid formed, whereas, according to the Poitevin–Vogel theory the result of the action should be the formation of an iodo-substitution compound.

1. Silver iodide was precipitated in the presence of a slight excess of potassium iodide, and thoroughly washed. A small quantity of pyrogallol was added and the mixture was exposed to sunlight for fifteen minutes in contact with water. The liquid at first neutral, at the end of fifteen minutes, showed a distinctly acid reaction, increasing with continued exposure.

[Pyrogallol was used in preference to tannin (gallotannic acid) because the former is perfectly neutral to test paper, and cannot confuse the reaction as would be the case with tannin, which of itself reddens blue litmus paper].

Again: if the Poitevin–Vogel theory were correct, it would afford a criterion as to what substances should, and what should not, exalt the sensitiveness of the silver haloids. Substances having an affinity for iodine should increase the sensitiveness, and substance not possessing such affinity, should have no such action. This is not the fact. There are substances which exalt an affinity for iodine, that do not exalt the sensitiveness of silver iodide and conversely, for example:

2. Silver iodide was exposed to light for a month under a solution of potassium carbonate, in a test tube, with another test tube, for comparison, containing silver iodide under water only. The alkali did not in the least increase the tendency of the iodide to darken.

3. Starch, which has a well-known affinity for iodine, does not appear to increase the sensitiveness of silver iodide by contact with it.

These experimental results appear to be incompatible with the Poitevin–Vogel theory.

The view which I have here offered is, moreover, very strongly supported by the phenomena of alkaline development. When a sensitive surface has been exposed to light, the image may be developed by pyrogallol, a neutral organic substance. This development is greatly stimulated by the presence of an alkali, a fact which the Poitevin–Vogel theory leaves unexplained. But according to the view here proposed, viz: that the result of the action of the organic body is not a substitution product, but a halogen acid, (e. g. HI, etc.), it is natural that the presence of an alkali should increase the tendency to form an acid for which it has a strong affinity.

Also, this new explanation is in harmony with received views of the action of the halogens in analogous cases, and particularly with that of the action of chlorine in bleaching organic substances. The modern view of the action is, not that the chlorine attracts the organic body with formation of a substitution compound, but that, by the coöperating affinity of the organic substance for oxygen, and that of the chlorine for hydrogen, an atom of water is decomposed, with formation of hydrochloric acid and peroxide of hydrogen, which latter substance attacks the oxidizable organic body. It will be observed that the reaction is exactly the same in both cases, the bleaching and the photo chemical. In fact, the parallelism is in all respects as complete as it can possibly be, and the analogy lends a strong support to the view that I have here expressed.

I conclude, therefore, that such organic bodies as increase the sensitiveness of the silver haloids to light, do so, not by forming substitution compounds with the halogen, but by promoting, in virtue of their affinity for oxygen, the decomposition of water by the halogen.

There is, probably, another affinity which plays some part in the tendency to form the halogen acid, and that is the tendency shown by the silver haloid to form combinations with the corresponding halogen acids, e. g. hydroargentic iodide AgIHI, etc., in the absence of an alkali.

Philadelphia, June 26, 1877.

ART. XVI.—*On Critical Periods in the History of the Earth and their Relation to Evolution: and on the Quaternary as such a Period;*[*] by JOSEPH LECONTE.

IN the series of rocks representing the history of the earth there occur at different horizons, *unconformities.* In most cases these do not occur at the same horizon in different places; but there are a few which seem to be very general. Associated with these unconformities, as is well known, there is nearly always a marked change in the fossil species. The greatness of this change is always in direct proportion to the generality of the unconformity. These general unconformities attended with very great changes in organic forms are the natural boundaries of the great divisions of time, and the less general unconformities attended with less sweeping change of organic forms, of the subdivisions.

The earlier geologists, under the influence of the *then* dominant idea of frequent supernatural interference with the course of nature, imagined that these unconformities marked the times of instantaneous cataclysm which disturbed the rocks and destroyed all living things, sometimes locally, sometimes generally; and that these exterminations were followed by re-creations of other and wholly different species at the beginning of the subsequent period of tranquility. *Now,* however, we believe that no such instantaneous general exterminations and re-creations ever occurred. Now we know that unconformity simply indicates eroded land-surface, and therefore marks a period of time during which the observed place was land and received no sediment—that two series of rocks unconformable to each other indicate two periods of comparative quiet, during which the observed place was sea-bottom receiving sediment steadily, separated by a period of oscillation producing increase and decrease of land, during which the observed place was raised into land-surface with or without crumpling of the strata, deeply eroded and then sunk again below sea level to receive the second series of strata. The length of the two periods of repose is roughly measured by the thickness of the two conformable series. The length of the period of commotion is roughly measured by the amount of erosion at the line of unconformity.

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[*] **Read before the National Academy of Sciences, April 18, 1877.**

Evidently, therefore, every case of unconformity marks a period of time, often a long period, during which there was no record made in strata and fossils at the observed place; certain leaves, often very many, are there missing from the Book of Time. Is it any wonder then, that skipping over these pages when we commence reading again we find the matter entirely new? Evidently, then, the suddenness of the change in organic forms is only apparent. If we could recover the record, which was doubtless carried on elsewhere, the break would disappear; if we could recover the missing leaves the reading would be continuous. In every such case therefore there is a *lost interval* of history. In cases of local unconformity we recover the lost record in other places, and thus fill up the blank in the history. But in some cases of very general unconformity, such as those which mark the great divisions of time, the loss is not yet recovered, perhaps is irrecoverable; though doubtless the more complete knowledge of the geology of the whole earth-surface will go far toward filling blanks and making the record continuous.

The view above presented is now held by all geologists, but there seems to be danger, under the influence of the *now* dominant views of evolution, of erring on the other extreme. Assuming a *uniform rate* of evolution, many, it seems to me, commit the mistake of measuring the amount of lost interval by the amount of change of organic forms, and thus discredit the real value of the geological record by exaggerating greatly its fragmentary character. On the contrary there seems good reason to believe that the evolution of the organic kingdom, like the evolution of society and even of the individual, has its periods of *rapid movement*, and its periods of *comparative repose* and re-adjustment of equilibrium. Geological history, like all other history, has its periods of comparative quiet, during which the forces of change are gathering strength; and periods of revolution during which the accumulated forces manifest themselves in conspicuous changes in physical geography and climate, and therefore in rapid movement in the march of evolution of organic forms—periods when the forces of change are *potential*, and periods when they become *active*. Conformable rocks represent the periods of comparative quiet, during which organic forms are either permanent or change slowly; unconformity represents a time of oscillation with increase and decrease of land, and therefore of rapid changes of physical conditions and correspondingly rapid movement in evolution. The general unconformities, of course, mark times of very general commotion—of wide-spread changes of physical geography and climate, and therefore of exceptionally rapid and profound changes in organic forms.

These periods of revolution in all history are *critical;* and therefore are of especial interest to the philosophic historian and to the evolutionist; but they are also in all history periods of *lost record.* And as in human, so also in geological history, the farther back we go, the longer are the lost intervals and the more irrecoverable the lost records. We will now give examples of such lost intervals and show their significance in evolution.

The first and by far the greatest of these lost intervals is that which occurs between the Archæan and the Paleozoic. In every part of the earth where the contact has been yet observed the Primordial lies unconformably on the upturned and eroded edges of the Archæan strata. This relation was observed first in Canada, then in various parts of the eastern United States, then in Scotland, Hebrides, Bavaria, Bohemia, Scandinavia. Unconformity in such widely separated localities, indicates wide-spread changes in physical geography, and therefore presumably of all those physical conditions included in the word *climate.* These changes of physical geography are best illustrated in the United States. The break between the Archæan and the Primordial has been observed in very many places all over the wide area of the United States east and west; not only in Canada, in New York, in the Appalachian region, in Wisconsin, Missouri, Arkansas and Texas, but also all over the Rocky Mountain region, in Nebraska, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico and Arizona. As upturned eroded outcropping strata mean land-surface, it is evident that there was at that time *a very large area, or else several large areas of land,* in the place now occupied by the American Continent. In comparison with the subsequent Silurian it was *a continental Period.* This land is often spoken of as *Archæan land.* It was indeed land of *Archæan rocks,* but for that very reason not of Archæan times: for these rocks were of course formed at the bottom of the sea in Archæan times, and therefore these localities were all sea-bed receiving sediment at that time. We know absolutely nothing of the land of Archæan times, and never can know anything until we find still older rocks from the debris of which Archæan sediment, were formed. The land spoken of above, was *land of the Lost Interval.* That the interval was immensely long is evident from the prodigious erosion. That it was a period of wide-spread oscillation is also evident; for all the places mentioned were sea-bed in Archæan, land during the interval, and again sea-bed during the Silurian. But of this long interval not a leaf of record remains.

Evidently then at the end of the Archæan an enormous area of Archæan sea-bottom was raised up and crumpled and became land. After remaining land for a time sufficiently long to allow enormous erosion of the crumpled strata it again went down to the old Primordial shore-line and the Silurian age commenced. This time of elevation is the lost interval.

Now, when the record closed in the Archæan, as far as we know, only the lowest forms of Protozoan life yet existed. The beginnings of life had not yet differentiated into what might be called a fauna and flora. When the record again opened with the Primordial we have already a varied and highly organized fauna, consisting of representatives of many classes and of all the great types of animal structure, except vertebrates. Nor are these representative the lowest in three several departments; for Trilobites and Orthoceratites can hardly be regarded as lower than the *middle of the animal scale* as it now exists. It is certain therefore that all the great departments except vertebrates, and most of the classes of these departments including animals as least half way up the animal scale, were differentiated during the lost interval. The amount of evolution during this interval cannot be estimated as less than all that has taken place since. Measured by the amount of evolution therefore, this lost interval is equal to all the history of the earth which has elapsed since. We escape this very improbable conclusion, only by admitting *a more rapid rate of evolution during critical periods.*

It is one of the chief glories of American Geology, to have first established the Archæan as one of the primary divisions of time. It is even yet reluctantly admitted as such by many European geologists. And yet, it is seen, that from every point of view, whether of the rock system or of the life system, it is by far the most widely and trenchantly separated of all the eras.

The next greatest lost interval (though far less than the preceding) is that between the Paleozoic and the Mesozoic. Here we have the next most general unconformity, indicating the next most wide-spread changes of physical geography and climate, accompanied by the most sweeping changes in organic forms, not only in species and genera, but also in families and orders. This change is the more striking as it occurs in the midst of an abundant life. It is the greatest and most sweeping change in the forms of organisms which has ever occurred in the history of the earth. *It took place, again, during a lost in-*

terval. A portion of the loss is recovered in the Permian; but the most critical time, the time of most rapid change, viz: that between the Permian and the Trias, is still missing. How we long to find the steps of this great change! What a flood of light would it shed on the process of evolution! But although the change in the organic kingdom was, just here, so enormously great, yet the lost interval does not seem very long; for in England the Trias and Permian seem to be conformable, though probably with change from marine to fresh water conditions. It is impossible therefore to resist the conclusion that the steps were just here fewer and longer, and the progress more rapid than usual. As in human history revolutions are the times of the birth of new social ideas, upon which during the subsequent period of tranquillity, society is re-adjusted in prosperity and happiness on a higher plane; so also in geological history, critical periods are times of origin of new and higher organic forms and the subsequent periods of tranquillity are times of re-adjustment of equilibrium and prosperous development of these forms.

Like the previous lost interval, this was also a period of oscillation—a period of great increase of land, which was again partly submerged to inaugurate the Trias. It was therefore, again, *a continental period.* The land-making commenced at the end of the Coal period, in this country with the formation of the Appalachian Mountains, continued through the Permian and culminated in the lost interval, which is in fact for that very reason lost.

Far less in length of time and perhaps in the sweeping character of the change of organisms, but far more important and interesting on account of the high position of the animals involved is the lost interval between the Mesozoic and Cenozoic. The length of time lost here is comparatively small. In America in many parts of the west the uppermost Cretaceous seems to pass into the lowermost Tertiary without the slightest break of continuity. There may be some break, some unconformity, some lost record, but certainly it cannot be large. Yet the change especially in the higher animals is immense. In America the break and the lost interval is much greater between the Jurassic and Cretaceous than between the Cretaceous and Tertiary, yet the organic change is far greater in the latter case. The reason is that the changes of physical geography and climate in the latter were *more general.* Although in America the break and the lost interval is greater at the end of the Jurassic, yet taking the strata all over the earth, the break is far more general at the end of the Cretaceous; and it is these *general* changes in physical geography which affect climate the most and which therefore produce the profoundest changes in organic forms.

Now it is almost impossible to imagine a clearer proof of the fact of rapid evolution-movement during critical periods, than we find in the shortness of the lost interval and yet the greatness of the change in higher organisms just at this horizon in the rocky series. Nothing can be more astonishing than the abundance, variety and prodigious size of Reptiles in America up to the very close of the Cretaceous, and the complete absence of all the grander and more characteristic forms in the lowest Tertiary; unless, indeed, it be the correlative fact of the complete absence of mammals in the Cretaceous and their appearance in great numbers and variety in the lowest Tertiary. If Cretaceous mammals existed in *America*, surely their remains would have been found in the wonderfully rich Cretaceous strata. It seems certain that in America, or at least in that portion which has been examined, mammals appeared somewhat suddenly and in great numbers on the scene and were a principal agent in the extermination of the great reptiles. The wave of reptilian evolution had just risen to its crest and perhaps was ready to break, when it was met and overwhelmed by the rising wave of mammalian evolution.

We have dwelt only on the great change in the higher classes, but the change really extended to all classes. This was therefore a time of exceptionally general and rapid changes in all departments alike. In other words it was a critical period in organic evolution.

That it was also a time of very great changes in Physical geography, here in America as well as elsewhere, is well known. The Cretaceous sea which extended from the Gulf of Mexico to the Arctic Ocean, covering the whole western plains and plateau region, and thus divided the American continent into two, an eastern Appalachian continent and a western or Basin region continent, was abolished at the end of the Cretaceous, and replaced by great fresh water lakes in the same region, and the continent became one. Moreover it is probable that it was a period of wide-spread oscillation, i. e., of upheaval and again subsidence to the condition of things found at the beginning of the Tertiary. It is probable that the upheaval which abolished the Cretaceous sea went much beyond the condition of things afterwards—that just at the interval the land was higher and larger than in the Tertiary—that, in short, this was again a *continental period* and probably a period of greater cold than the subsequent Tertiary.

The change in physical geography, then, was immense, but in most places by bodily upheaval, not by crumpling of the strata, and therefore the usual signs of such change, viz: unconformity is often wanting. The change of climate all over the American continent was no doubt very great and the change in organic forms correspondingly great everywhere and in all departments; but this was especially true of all water-inhabiting species, in the region of the old Cretaceous interior sea; for here there was a change not only in climate but from salt to fresh water through the intermediate condition of brackish water. The Cretaceous marine species rapidly disappeared, partly by extermination and partly by transmutation into fresh water species, as has been observed, recently, to take place in some crustaceans under this change of conditions.* The Tertiary fresh-water species rapidly appeared partly by transmutation from the previous marine and partly by transportation in various ways from other fresh lakes. But all this occurred in some places without the slightest break in the continuity of the strata.

The great change of climate and other physical conditions perhaps sufficiently explain the change in *invertebrate* species, but it is impossible to account for the somewhat sudden appearance of mammals in the lowest Tertiary except by *migration* from other regions where they had existed in late Cretaceous times, having originated there by derivation in the usual way. That marsupials existed somewhere in Cretaceous times (though possibly not in America or Europe) there can be no doubt; for they existed we know in the preceding Jurassic and the following Tertiary, and they exist *now.* It is from these rather than from Cretaceous reptiles, that Tertiary mammals were doubtless derived; and this derivation took place probably at rapid rate in the latest Cretaceous or during the lost interval in some unknown locality whence they migrated into the Tertiary lake region of the United States during the interval. This migration came most probably from northern Asia; for it must be remembered that the interval was a continental period and therefore probably a period of broad land connections between Nearctic and Palearctic regions. The complete examination of the uppermost Cretaceous of different portions of Asia will probably reveal the immediate progenitors of the early Tertiary mammals of Europe and America. This introduces us to a most important element of rapid local faunal change especially in higher animals, viz: *migrations.* If we do not dwell longer now on this, it is only because we shall have to recur to it again.

I have preferred, thus far, to speak of *general* evolution-changes of organisms, whether slow or rapid, as produced by varying pressure of external conditions; and the most striking *local* changes by migrations from other regions where the apparently suddenly-appearing species had previously existed, having originated there by evolution in the usual way. I have preferred, thus far, to represent the organic kingdom as lying, as it were, *passive* and plastic under the moulding hands of the environment. I have done so because it is in accordance with true method to exhaust the more obvious causes of evolution before appealing to the more obscure and doubtful.

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* Arch. des Sciences, Nov., 1875, p. 284.

It is possible that general movements affecting alike all classes may be accounted for in this way alone. But there are many facts in the evolution of the organic kingdom, especially the sudden appearance of new forms in the quietest times, which can hardly be thus explained. There seem to be *internal* as well as *external* factors of evolution. Again the internal factors may be either in the form of *tendencies* to change or of *resistance* to change. Of these, however, the latter seems to be most certain. There may be in the organic kingdom an "*inherent tendency*" to change in special directions, similar to that which directs the course of embryonic evolution—a tendency, in the case of the organic kingdom, inherited from physical nature from which it sprung, as in the case of the embryo it is inherited from the organic kingdom through the line of ancestry. This cause, however, is too obscure, and I therefore pass it by.

But whether or not there be any such inherent tendency to change, there certainly is an inherent tendency to *stability*—to persistence of organic form. If there be no inherent force of progress, there certainly is an inherent force of *conservation* greater in some species than others. It seems probable that in many of the more rigid types this stability is so great, and therefore variation of offspring is so slight, that progressive change of form is too slow to keep pace with change of external conditions especially in critical periods. If this be so, then an organism may be regarded as under the influence of two opposing forces, the one conservative, the other progressive; the one tending to equilibrium, the other to motion; the one to permanence, the other to change of form; the one static, the other dynamic; the one internal, *the law of heredity*, the other external, the *pressure of a changing environment.* Under the influence of two such forces, the one urging, the other resisting, it is evident that even with steady changes of external conditions, the change of organic forms would be more or less paroxysmal. Other kinds of evolution, physical and social, evidently advance paroxysmally from this cause. As therefore in the gradual evolution of earth-features there are periods of comparative quiet, during which the forces of change are gathering strength, but produce little visible effect, being resisted by crust-rigidity, and periods when the accumulating forces finally overcome resistance and determine comparatively rapid changes; as also in social evolution there are periods in which forces of social change are gathering strength, but make no visible sign, being resisted by social conservatism—rigidity of the social crust—and periods in which resistance gives way and rapid changes occur; so also in the evolution of the organic kingdom the forces of change, i. e. pressure of changing environment, may accumulate but make little impression, being resisted by the *law of heredity*—of *like producing like*—or type-rigidity, untill finally the resistance giving way, the organic form breaks into fantastic *sports* which are at once seized by natural selection and rapid change is the result.

Some persons seem to think that paroxysmal evolution is inconsistent with the uniformity of Nature's laws. On the contrary, it is in perfect accord. Laws and forces are indeed uniform, but phenomena are nearly always paroxysmal. The forces of volcanos and earthquakes, of lightning and tempests are uniform, but the phenomena are paroxysmal. Winds at the earth's surface, where the resistance is great, *blow in puffs.* A thin sheet of water over a smooth sloping surface *runs in waves.* The law may be illustrated in a thousand ways. In all cases where an accumulating force is opposed by a constant resistance, we have phenomena in paroxysms.

But whatever be the cause, the *fact* of paroxysmal movement of organic evolution is undoubted. All along the course of geological history, from beginning to end, even when the times were quietest, where the record is fullest and apparently without any missing leaf, species come and go and others take their place, and yet only rarely do we find any transition-steps. If this were only once or twice or thrice, or to any extent exceptional, it might be explained by loss of record here and there, but it occurs thousands and tens of thousands of times. Now if evolution moves only at uniform rate—if it takes 100,000 years to transmute one species into another (as it certainly does when evolution is moving at its usual rate)—if there are at least 100,000 steps (represented each of course by a whole generation of many individuals), between every two consecutive species, it is simply incredible that all the individuals representing the intermediate steps, so infinitely more numerous than the species they connect, should be so generally, almost universally lost. But the phenomena as we find them, are easily understood, if a few generations represent the transition step, and many generations the permanent form.

A similar rapid, almost sudden appearance and extinction of *genera, families* and higher groups at certain horizons, are also common. In these cases the intermediate steps of transition are often found, and constitute in fact the chief demonstrative evidence of the truth of evolution. But the difficulty on the assumption of a uniform rate of evolution is none the less here, for the time required to evolve a new genus or a new family is of course immensely greater than in the case of a new species.

We will illustrate the difficulties of the ordinary view by one striking example. In the Upper Silurian in the midst of a conformable series, where if there be any break—any lost record—surely it must be very small, appear suddenly, without premonition, *Fishes:* not a connecting link between fishes and any form of invertebrates, but perfect, unmistakable fishes. Here we have, therefore, the appearance not only of a new class, but of a new sub-kingdom or type of structure, *Vertebrata.* Now to change from any previously existing form of invertebrate, whether worm, crustacean or mollusk, into a vertebrate, by a series of imperceptible steps represented by successive generations—steps so imperceptible that it would take 100,000 of them to advance from one intermediate species to another—would require an amount of time which is inconceivable to the human mind, and a number of steps, each be it remembered, represented by thousands of individuals, which can scarcely be expressed by figures. And yet we must believe that these innumerable transitional forms, each represented by innumerable individuals, are all lost, and that this prodigious time shows no evidence in the rocky record. If this case were exceptional we might possibly admit that fishes appeared in Great Britain by migration (as they probably did), but only after having previously existed untold millions of ages, somewhere else; but similar cases are too common to be explained in this way.

Now the whole difficulty disappears—we avoid the incredible imperfection of the geological record (imperfect at best)—we avoid also the necessity of extending geological time to a degree which cannot be accepted by the physicist—if we admit that the derivation of one species from another is not necessarily by innumerable imperceptible steps, but may sometimes be by a *few decided steps;* and that the same is true for the origin of new genera, families, orders, etc.; in a word, that there are in the history of evolution of species, genera, families, orders, etc., and of the organic kingdom, *periods of rapid movement.* When the whole organic kingdom is involved in the movement, then we call the period *critical,* and the record of it is often lost.

Thus, on the supposition of such rigidity or resistance to change, in organic forms, varying in degree in different species and in different genera, families, orders, etc., a rigidity, also, *increasing by accumulated heredity so long as conditions remain unchanged,* it is evident that, in times of perfect tranquility all species grow more and more rigid. In times of very gradual change, the more plastic species change gradually *pari passu,* while the more rigid species change paroxysmally, now one, now another, as their resistance is overcome. Finally, in times of revolution nearly all forms yield to the pressure of external conditions and change rapidly; *only the very exceptionally rigid being able to pass over the interval to the next period of re-adjusted equilibrium.*

Thus, for example, the great and wide-spread changes of physical geography which occurred at the end of the Carboniferous, appropriately called in this country, the *Appalachian revolution,* was the death-sentence of the long-continuing and therefore rigid Paleozoic types. But the sentence was not immediately executed. The Permian represents the time between the sentence and the execution—the time during which the more rigid Paleozoic forms continued to linger out a painful existence in spite of changed and still changing conditions. But the most critical time—the time of most rapid change—the time of actual execution—was the *lost interval.* Only a very few most rigid forms pass over this interval into the Trias.

The Quaternary, a Critical Period.

We have given examples of several general unconformities, the signs of wide-spread oscillations of the earth-crust, attended with increase and decrease of land, and therefore with great and wide-spread changes of climate and other physical conditions, and therefore also with great and rapid changes of organic species. These times of general oscillation are therefore the natural boundaries of the Eras or primary divisions of Time. We have called them critical periods, transition-periods, periods of revolution, because they are times of rapid change, both in the physical and the organic world—a change overthrowing an *old* and establishing a *new* order of things. They are also times of *lost record.* We have seen, also, that these critical periods, in comparison with the preceding and succeeding, are *continental periods*, and it is for this reason that their record is usually lost.

Now, the Quaternary is also such a critical or transition period, marking the boundary between two great Eras. The Quaternary is also a period of great and wide-spread oscillations, with increase and decrease of land—a period of upheaval, erosion, down-sinking, to rise again slowly to the present condition. The early Quaternary was, also, therefore, to a marked degree, a continental period. Here also we have newer rocks lying unconformably on the eroded edges of an older series—river sediments in old river valleys, marine sediments in fiords—in other words, we have unconformity on a grand scale. Also in connection with these oscillations we have great changes in physical geography, and corresponding and very wide-spread changes in climate, and therefore corresponding rapid changes in organic forms. Here then we have all the characteristics of one of the boundaries between the primary divisions of time. Here then we have a transition or *critical* period—a period corresponding to one of the lost intervals; only in this instance being so recent, and being also less violent than the preceding ones, *it is not lost.* The study of the Quaternary, therefore, ought to furnish the key which will unlock many of the mysteries which now trouble us. Some of the problems which have been or will be explained by study of the Quaternary, we will now briefly mention.

I. *Changes of species not sudden.*—If the Quaternary were lost and we compared the Tertiary rocks with the unconformably overlying recent rocks, and the Tertiary mammals with those now living, how great and apparently sudden seems the change! How like to a violent extermination and re-creation! But the Quaternary is fortunately not lost, and we see that there has been no such wholesale extermination and re-creation, but only gradual though comparatively rapid change.

II. *Migration one chief cause of change.*—But what is still more important, we are able to trace with something like certainty, the cause of these rapid changes, and we find that in the higher animals, chief among these have been *migrations*—migrations enforced by changes of climate, and migrations permitted by changes of physical geography opening gateways between regions previously separated by impassable barriers. This point is so important that we must dwell upon it. Only an outline, however, of some of these migrations and their effects on evolution can be given in the present condition of knowledge.

During Miocene times, as is well known, evergreens, allied to those now inhabiting Southern Europe, covered the whole of Europe as far north as Lapland and Spitzbergen. In America, Magnolias, Taxodiums, Libocedrus and Sequoias very similar to, if not identical with those now living on the Southern Atlantic and Gulf coast and in California, were abundant in Greenland. Evidently there could have been no *Polar ice-cap* at that time and therefore no Arctic species unless on mountain tops. During the latter part of the Pliocene the temperature did not differ much from the present; the polar ice-cap had therefore commenced to form, with its accompaniment of Arctic species. With the coming on of the *Glacial epoch*, the polar ice and Arctic conditions crept slowly southward, pushing Arctic species to middle Europe and Middle United States, and sub-Arctic species to the shores of the Mediterranean and the Gulf. With the return of more genial climate, Arctic conditions went slowly northward again, and with them went Arctic species slowly migrating generation after generation to their present Arctic home.

Similarly molluscous shells migrated slowly southward and again northward to their present position. But *plants* and some terrestrial invertebrates, such as *insects*, had an alternative which shells had not, viz: that of seeking Arctic conditions also *upward* on the tops of mountains. Many did so and were left stranded there until now. It is in this way that we now account for the otherwise inexplicable fact that Alpine species in Middle Europe are similar or even largely identical with those in the United States, and both with those now living in Arctic regions. These species were widespread all over Europe and United States in Glacial times; and while some of them afterward went northward to their present home, some in each country sought Arctic conditions in Alpine isolation. This explanation, which has been long recognized for plants, has been recently applied by Mr. Grote, also to Arctic insects found on the top of Mt. Washington and the mountains of Colorado.*

Undoubtedly changes of climate during this time enforced similar migrations among mammals also. But it is evident that while plants and invertebrates might endure such changes of climate and such enforced migrations with little change of form, the more highly organized and sensitive mammalian species must be either destroyed or else must undergo more profound changes. Moreover, the opening of land-connections between regions previously isolated by barriers would be far more quickly taken advantage of by mammals than by invertebrates and plants. The migrations of plants are of necessity very slow, i. e., from generation to generation. The migrations of mammals too, so far as they are *enforced* by changing climate, are of a similar kind; but the voluntary migrations of mammals *permitted* by removal of barriers may take place much more rapidly—even in a few generations. This introduces another element of very rapid local change, viz: the *invasion* of one fauna by another equally well adapted to the environment, and the struggle for life between the invaders and the autochthones.

For example: in America during the Glacial epoch, coincidently with the rigorous climate, there was an elevation of the continent, greatest in high latitude regions, but also probably greatest along the line of the Mississippi River; for in this region it extended southward even to and beyond the shores of the Gulf. Professor Hilgard has shown that the elevation at the mouth of the Mississippi River was at least 450 to 500 feet above the present condition. Until the Glacial times the two Americas were certainly separated by sea in the region of the Isthmus, as shown by the Tertiary deposits there. This barrier was removed by upheaval during the Glacial epoch,

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*** This application, with reference to Mount Washington and other Arctic insects in America, was previously made by Prof. A. S. Packard, Jr., in the Memoirs of the Boston Soc. Nat. Hist., i, p. 256, 1867.—Eds.**

and a far broader connection existed *then* than now. Through this open gateway came the fauna of South America, especially the great Edentates, into North America. Similarly a broad connection then existed between America and Asia in the regions of the shallow sea between the Aleutian Isles and Behring Straits. Through this gateway came an invasion from Asia, including probably the Mammoth. With this invasion probably came also Man. It seems probable, therefore, that the earliest remains of man in America will be found on the Pacific coast.

Also the great Pliocene Lake, which stretched from near the shores of the Gulf far into British America, and possibly into Arctic regions, and formed a more or less complete barrier to the mammalian fauna east and west, *was abolished* by upheaval, and free communication was established. It is impossible that all these changes of climate and all these migrations, partly enforced by changes of climate and partly permitted by removal of barriers, and in this latter case especially attended with the fiercest struggle for life, should not produce rapid and profound changes in the mammalian fauna.

In Europe the process has been more accurately studied and is better known. In Quaternary times at least four different mammalian faunæ struggled for mastery on European soil. 1. The Pliocene Autochthones. 2. Invasions from Africa by opening of gateways through the Mediterranean—one by way of Italy, Sicily and Malta, and one by Gibraltar, both of which have been again closed. 3. Invasions from Asia, by removal of a great sea-barrier connecting the Black and Caspian with the Arctic Ocean. This gateway has remained open ever since. 4. Invasions from Arctic regions enforced by changes of climate. Probably more than one such invasion took place: certainly one occurred during the second Glacial epoch. The final result of all these climatic changes and these struggles for mastery was that the Pliocene Autocthones, adapted to a more genial climate, were mostly destroyed or else driven southward with some change into Africa; the African invaders were driven back also into Africa, and with some Pliocene Autocthones isolated there by subsidence in Mediterranean region closing the southern gateways, and still exist there under slightly modified forms; the Arctic invaders were again driven northward by return of more genial climate, and there remain to this day; while the Asiatics remained masters of the field, though greatly modified by the conflict. Or perhaps more accurately we might say that the existing European mammalian fauna is a resultant of all these factors, but the controling factor is the Asiatic. With the Asiatic invasion came man, and was a prime agent in determining the final result.

Thus, regarding the Tertiary and the Present as consecutive Eras and the Quaternary as the transition or critical period between; then, if the record of this period had been lost, corresponding with the unconformity here found, we should have had here an enormous and apparently sudden change of mammalian species. Yet this change of fauna, as great as it is, is not to be compared with that which occurred between the Archaean and Paleozoic, or between the Paleozoic and Mesozoic, or even that between the Mesozoic and Cenozoic; for the change during the Quaternary is mostly confined to species of the higher mammals, while the change during previous critical periods extended to species of all grades: and not only to species, but to genera, families, and even orders. We conclude, therefore, that *the previous critical periods or lost intervals were far longer than the whole Quaternary; or else that the rate of evolution was far more rapid in these earlier times.*

To sum up then in a few words the general formal laws of evolution-change throughout the whole history of the earth:

1. Gradual, very slow changes of form everywhere under the influence of all the factors of change, known and unknown—e. g., pressure of changing physical conditions whether *modifying the individual*, certainly one factor, or *selecting the fittest offspring*, certainly another factor; improvement of organs by use and the improvement inherited, certainly a third factor, and perhaps still other factors yet unknown. This general evolution by itself considered would produce similar changes everywhere, and therefore would produce geological faunæ, but not geographical diversity. Determination of a geological horizon would in this case be easy, because fossil species would be identical everywhere.

2. Changes in different places and under different physical conditions taking different directions and advancing at different rates, give rise to *geographical faunæ*. This, if there were nothing more, would produce far greater geographical diversity and more complete localization of faunæ and floræ than now exists; so great that the determination of a geological horizon would be impossible.

3. The forces of change resisted by heredity, in some species and genera more than others, determines paroxysms of more rapid movement of general evolution affecting sometimes species, sometimes genera or families. The sudden appearance of species, genera, families, etc., in quiet times is thus accounted for.

4. *During critical periods*, oscillations of the crust, with rapid changes of physical geography and climate, determine a more rapid rate of change in all forms, 1st, by *greater pressure of physical conditions*, and, 2d, by *migrations* partly enforced by

the changes of climate and partly permitted by removal of barriers, and the consequent *invasion* of one fauna and flora by another and *severe struggle* for mastery. This would tend to *equalize again* the extreme diversity caused by the second law; but the effect would be more marked in the case of animals than plants because voluntary migrations are possible only in this kingdom. Hence it follows that *a geological horizon is far better determined by the fauna than by the flora.*

III. *Historic value of the Present time.*—Most geologists regard the Present as one of the minor subdivisions of the Cenozoic Era, or even of the Quaternary period. More commonly the Quaternary and Present are united as one age—the age of man—of the Cenozoic Era. The Cenozoic is thus divided into two ages; the age of mammals commencing with the Tertiary, and the age of man commencing with the Quaternary; and the Quaternary subdivided into several epochs, the last of which is the Present or Recent. But if the views above expressed in regard to critical periods, be correct, then the Present ought not to be connected with the Quaternary as one age, nor even with the Cenozoic as one era, but is itself justly entitled to rank as one of the *primary divisions* of time, as one of the great eras separated like all the other eras by a critical period; less distinct it may be, at least as yet, in species than the others, the inaugurating change less profound, the interval less long, but dignified by the appearance of man as the dominant agent of change, and therefore well entitled to the name *Psychozoic* sometimes given it. The geological importance of the appearance of man is not due only or chiefly to his transcendent dignity, but to his importance as an agent which has already very greatly, and must hereafter still more profoundly, modify the whole fauna and flora of the earth. It is true that man first appeared in the Quaternary; but he had not yet established his supremacy; he was still fighting for mastery. With the establishment of his supremacy the reign of man commenced. An age is properly characterized by the *culmination*, not the first appearance, of a dominant class. As fishes existed before the age of fishes, reptiles before the age of reptiles, and mammals before the age of mammals, so man also appeared before the age of man.

We, therefore, regard the Cenozoic and Psychozoic as two consecutive eras, and the Quaternary as the critical, revolutionary or transitional period between. But since the record of this last critical period is not lost and we must place it somewhere, it seems best to place it with the Cenozoic Era and the mammalian age, and to commence the Psychozoic Era and age of man with the completed supremacy of man, i. e. with the Present epoch.

Berkeley, California, March 15, 1877.

ART. XVII.—*Notes on the internal and external structure of Paleozoic Crinoids;* by CHARLES WACHSMUTH.

THE structure of fossil Crinoids has occupied the attention of many able writers, and numerous ingenious and plausible theories have been advanced to demonstrate the physiological functions of the various parts of their complicated organization. The results of investigations heretofore made have been by no means harmonious, and newly discovered evidence renders many of these theories wholly unsatisfactory. I have been favored with unusual facilities for obtaining accurate knowledge upon many of the questions involved in these researches, and therefore hope that I may contribute useful information on the subject. The collections of eighteen years at Burlington, Iowa, have brought to light material, unrivaled elsewhere, for this study. I have obtained upwards of four hundred species of Crinoids at that locality, many of the specimens in such a condition, that not only the whole calcareous skeleton of the animal, but even the most delicate internal organs are preserved almost as perfectly as in those dredged from our present seas. Careful observations, extending through many years, and study of this material in connection with extensive collections from other formations, have enabled me to add to the present knowledge of these forms many interesting and important facts, and have led me to conclusions which I present in the following pages.

1. *The mouth and the tubular skeleton below the vault.*

The apparent absence of a mouth has proved to be one of the most perplexing points in the investigation of the structure of Paleozoic Crinoids. In all Radiates (even of the most inferior groups), this organ is located invariably *at one end of the vertical axis*, although that axis or center is not always the center of figure. It occupies in the recent Crinoids the upper end of this axis, but in many at least of the Paleozoic Crinoids, the portion of the summit, where from analogy, we should expect to find the oral aperture, is perfectly covered by solid and immovable plates. The only aperture in connection with the visceral cavity is lateral or subcentral, placed outside of the radiation and within the interradial area, where, from analogy, we must expect to find the anus. If, as Mr. Billings,* Dr. White† and the older writers on Crinoids supposed, this aperture served both as mouth and vent, so that these Crinoids took in their food through the anus, this stands as the sole exception to the rule governing the class. It is true, the Ophiurans, for instance, have no separate anal opening, and the same aperture performs both oral and anal functions, but it is placed within the radial center and therefore cannot be homologized with the interradial orifice of Paleozoic Crinoids. In *Antedon rosaceus*, although the nascent Crinoid develops already within the pseudembryo a separate mouth and vent, a single orifice serves for some time both as oral and anal aperture, yet it is the permanent mouth occupying the center of the ambulacral system.* While we thus find the mouth performing permanently or temporarily anal functions, we have on the other hand no evidence either from recent nature or from embryology that an anus ever becomes developed into, or performs the office of, a mouth.

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* This Journ., 1869, vol. xlviii, No 142, p. 69.

† Journ. Nat. Hist. Boston, 1862, vol. vii, No. 4, p. 481.

The Crinoids of our present seas live exclusively on microscopic food, and we must expect to find that the Paleozoic Crinoids subsisted upon very similar food and had a very similar mode of alimentation. Whenever in *Antedon* alimentary particles fall upon the furrows of the arms or pinnulæ, they are transmitted downward along these furrows to the mouth wherein the furrows terminate. Dr. Carpenter remarks on this subject:†

"The transmission of alimentary particles along the ambulacral furrows is the result of the action of cilia with which their surface is clothed. Although I have not myself succeeded in distinguishing cilia on the surface which forms the floor of these furrows, yet I have distinctly seen such a rapid passage of minute particles along their groove as I could not account for in any other mode, and I am therefore disposed to believe in their existence. Such a powerful indraught, moreover, must be produced, about the regions of the mouth, by the action of the large cilia which fringe various parts of the internal wall of the alimentary canal, as would materially aid in the transmission of minute particles along those portions of the ambulacral furrows which immediately lead toward it; and it is, I feel satisfied, by the conjoint agency of these two moving powers, that the alimentation of Antedon is ordinarily effected."

It appears from these observations, that the mouth of Antedon has no special functions as such, but is merely a receiving center or general passage, into which the food which accidentally falls in contact with the furrows of the arms or pinnulæ, enters; a passage which might as well be external, hidden beneath a vault, as open to the surrounding element, provided the food could be brought in contact with it. The large cilia on the inner wall of the alimentary canal, which Dr. Carpenter describes as being capable of producing such a powerful indraught to the region of the mouth, afford, it seems to me, also a very satisfactory explanation of the mode by which the transmission of food was effected in Paleozoic Crinoids. How much more powerful must have been the effects of these cilia in individuals, in which mouth and furrow were arched over and in which the current was unobstructed from without. Considering, further, that probably the covered parts of the food channels themselves were fringed with cilia of similar functions, it could have been of but little moment how remote from the mouth the food entered. We find another most striking example in confirmation of this supposition in *Hypomene Sarsi* Lovèn, a recent Cystidian, indicating in analogy with recent nature that Crinoids had the mouth sometimes internal. Prof. Lovèn found in the covered parts of its channels microscopic Crustacea, larval bivalves, and other remains of the food of the animal, apparently taken through the open parts of the channels. Applying this observation to Paleozoic Crinoids it seems very probable that their food was taken up along the open parts of the arms or pinnulæ, and conveyed through the closed parts to the concealed mouth.

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* Sir Wyville Thomson, Phil. Trans. of the Royal Society.

† Researches on the Structure, Physiology and Development of *Antedon rosaceus*. Part I, by W. B. Carpenter, M.D., F.R.S., Phil. Trans. Roy. Soc., vol. clvi, Part II, 1866.

Dr. Ludvig Schultze, in his excellent "Monograph on the Echinoderms of the Eifel, Vienna, 1867," was, so far as I know, the first author, who suggested the idea, that all Crinoids which are covered on their ventral side by solid plates, and have but one orifice, were provided with an internal mouth. He further suggested, that the food was conveyed by the open food groove to the inner cavity through the arm-openings at the base of the arms, by means of subtegminal channels along the inner surface of the vault.

Dr. Lütken, fully confirming Dr. Schultze's observations, gives a full description of the ducts and subtegminal galleries, and compares these with the covered food grooves in *Hypomene Sarsi*, expressing the opinion, that the galleries underneath the summit, which he considered to be closed at the bottom and thus transformed into ducts, were food passages.

Meek & Worthen describe and figure in the Illinois Geological Report, vol. v, from my former collection, now in the Museum of Comparative Zoology at Cambridge, several specimens of well-preserved digestive organs, and also an *Actinocrinus proboscidialis*, in which a skeleton of tubular canals proceeds from a point below the central axis of the vault, to the arms. There are in that specimen five main tubes which bifurcate midway toward the arm bases, each division bifurcating again, sending a branch to each one of the twenty arms of that species. The main tubes and branches are constructed on their lower side of alternating plates, upon which on either side, a second row of minute quadrangular interlocking plates is attached, longitudinally arranged, thus covering the tubes. The upper rows of plates are not preserved in this specimen, but I have found them in two specimens of *Strotocrinus*, which I obtained recently, in which they are well preserved and in place. The condition of the specimen, as Meek & Worthen remark, leaves but little doubt, but that the tubes form through the arm-openings of the calyx a continuation of the arm furrows. In removing parts of the vault, I unfortunately broke the upper part of the fragile skeleton, but enough is preserved to prove that the five main tubes did not connect directly with each other, but communicated at their upper end separately, as it seems, with an annular vessel of which traces are yet preserved. Such a vessel was found in wonderful preservation in a specimen of *Actinocrinus Verneuilianus* Shum. The radiating canals were here not preserved, but the little openings, through which they communicated, are plainly visible in the circular organ. There are, at the lower side of the ring, which is composed of minute interlocking plates, five other small openings, which, alternating with the former ones, were apparently in connection with organs of the interradial system (communicating perhaps with a circulatory system). The whole upper part of the stomach is here placed within the ring,—differing in this particular from *Actinocrinus proboscidialis*, in which only a spiral alimentary tube passes out from the interior of the convoluted digestive organ. The several tubes of the skeleton, though closely following the direction of the vault, but without touching it, are placed here within some obscure furrows along its inner surface.

Such furrows in the vault can be observed in many Paleozoic Crinoids. They are either elevations of the vault itself or are formed by ridges or partitions on the inner surface, which are always deepest toward the anal side. The grooves are sometimes closed underneath, particularly in very old specimens, thus forming regular ducts or tunnels. Their arrangement seems to be similar in all these Crinoids, no matter whether the species has a subcentral proboscis or merely a lateral opening, they always diverge from a plane on the inner wall of the vault, in front of the anus, and branch to the arm openings.

For further information on this subject, I will now call attention to some most excellent natural casts, mostly of Actinocrinidæ, which I obtained from cherty layers of the Upper Burlington limestone. The outer shell or limestone test was generally attached when I found them, but so much decayed, that it was removed by the least touch. The substance of which the casts are formed appears to have been a fine silicious mud which could penetrate the smallest pores. The internal organs are of course not preserved, but their impressions at the surface of the casts throw much light on the structure beneath the vault. The center of radiation appears here a small pentagonal, rounded, or in species with strong subcentral proboscis, subtriangular or even heart-shaped space or plane, enclosed by a deep groove, from which, in some of these specimens, elevated ridges, alternating with depressions, pass out toward the arms; but before quite reaching them, there proceeds, from below the ridges of the casts to every arm, a smaller ridge which clearly indicates the tubular canal, as described in *Actinocrinus proboscidialis.* The casts are so perfect that I can even detect at some places the impressions of the alternating minute plates of the tubes.

The casts are easily understood, if we remember that the broader ridges are impressions of the grooves in the vault, and that the depressions correspond to the partitions which formed the grooves. The radiating tubes, where they do not appear in the casts, were evidently placed at some distance from the vault, and therefore enveloped and obliterated by the material forming the casts; but on approaching the arm-bases, they closely underlie the test, and their counterparts are preserved.

I have already mentioned in the casts a pentagonal space, surrounded by a furrow, as being the center of radiation. It is located anterior to the proboscis, occupying a central or nearly central position. The middle of the space is occupied frequently either by a small opening or by a little cone indicating an aperture leading toward the inner cavity, but in these casts the aperture is isolated, and there appears on the surface no connection with the annular groove surrounding it. To understand this structure it becomes necessary to examine first some other casts from the same locality, mostly of *Strotocrinus* and *Actinocrinus*, but also several of *Batocrinus*, though of different species from those which I have just described. These casts have no annular groove, and the radiation which is marked by elevated rounded ridges, almost like strings overlying the surface, proceeds from *a point in the center where I noticed the little aperture* in the former casts. The strings diverge toward the arm-bases in the same manner as the tubular canals; they are stronger toward the center, decreasing in size with each bifurcation. That these ridges are remains of muscular cords is not probable from the perishable nature of such organs, and they are not their casts, or they should have left depressions in place of elevations. They can only be casts of passages which communicated with the central aperture, and which were evidently yet preserved when the siliceous mud, forming the casts, penetrated the body, but, their calcareous parts becoming in the course of time decomposed, a cast was left only of their inner channel, and this explains their string-like appearance. The little central aperture, located at the upper end of the vertical axis, occupied on the casts, and hence below the vault of these Crinoids, exactly the same position that *the internal mouth of Antedon occupies at the peristome*, while the position of the string-like ridges (in case they represent passages as I can hardly doubt), is analogous with that of the *open food grooves* of recent Crinoids.

The annular groove on the casts is probably an impression of the annular *vessel* of which the calcareous parts have decomposed. This organ, in the fossil state, heretofore only observed in the case of *Actinocrinus Verneuilianus*, existed undoubtedly in all Crinoids. That we find no trace of it in some of the casts is no proof to the contrary; it may have been sometimes composed of more perishable material and was not preserved, or situated at a greater distance from the vault and covered by the substance of which the casts were formed.

2. *The ventral furrow of the arms.*

The arms of Palæozoic Crinoids manifest great diversity in outer form and structure, but are invariably provided with a ventral furrow, which continues from the arm bases up to the tips of the arms and along the pinnulæ. The pinnulæ spring out alternately right and left from the arm-plates, their furrows connecting with that of the arm and forming in fact a continuation of the same.

The furrow appears, in specimens in ordinary preservation, as a simple groove, which communicates through the arm openings with the inner cavity of the body. Only in rare instances, has the furrow been found covered by minute plates, whose construction however has heretofore not been ascertained. The best specimen of this kind, that I have seen, is a *Cyathocrinus malvaceus*, in which the little plates above the furrow can be studied in all their details, with the greatest precision. The specimen is the property of Frank Springer, Esq., who had the kindness to leave it with me for investigation and description. The arms of Cyathocrinus are composed of long slender joints with a wide ventral furrow. They bifurcate frequently, each branch bifurcating at intervals again. There appears on the arms of *Cyathocrinus* no scar for the attachment of pinnulæ, and as these appendages have never been observed in the genus, it is probable that the many little branches performed their functions. In Mr. Springer's specimen the plates above the furrow consist of two rows of minute pieces, on either side, the inner rows of which join in the middle, interlock with each other, and form an apparently solid covering. The outer plates which are attached to the arm-joints are toward the upper end of the arms placed partly upon the edges of the joint, but nearer the calyx rest wholly against the edges of the upper part of the ventral furrow. They are longitudinally arranged, partly hidden from view by the inner plates. The visible part is quadrangular, with a narrow tooth-like projection toward the lower end of each plate, which is directed inward and slightly downward as a sharp, elongated process, and forms a support for the inner plates. The inner plates are elongated triangular, resting with their shorter sides against the inner faces of the outer series, and, between the tooth-like extensions, overlapping them with their beveled lateral edges, in such a manner that each plate exteriorly fits in and fills the space between each pair of similar triangular plates on the other side. The two longer sides interlock with corresponding sides of similar plates of the opposite row, their sharp angles or apices meeting the sutures between the opposite quadrangular plates. At each of these points of juncture, just beyond the apex of each triangular piece, on either side of the furrow, there is a little pore, which evidently communicates with the inner channel. There are six sets of plates to each arm-joint, all the plates being imbricated from the lower side upward,—that is, the lower ones lap slightly the edges of the upper ones —thus facilitating the movements of the arms.

In describing the skeleton below the vault, I suggested that the tubes were a continuation of the arm furrows. A transverse section of the arm, examined with the aid of a good magnifier, shows that the tubes themselves were, at least in this species, continued along the arms to their tips, and rested within the arm-furrow, with their sides closely attached to the upper edges of the arm-joint. The tubes do not touch the floor of the arm-grooves, but leave a good sized subtriangular channel underneath. The small plates, above described, form the upper or outer wall of the tube, and two sets of small plates enclose it below. The position of the two upper sets of quadrangular pieces is nearly erect, leaning inward, the triangular cross-pieces lying horizontally, thus forming a regular tube or tunnel with a nearly round channel.

I was at first of the opinion, after examining Mr. Springer's specimen, that the arm-furrows of Paleozoic Crinoids were permanently covered by solid plates, like the ventral side of their cup, but upon comparing these arms with those of a specimen of *Cyathocrinus viminalis* in my own collection, I became fully convinced, that the inner plates could be opened or shut at will by the animal. The arms of my specimen are spread out, their ventral furrows are open, the quadrangular pieces in place, their tooth-like extensions stand out like the teeth of a saw, and are so arranged that the indentations face the salient angles of the opposite side, thus giving to the furrow a strongly zigzag appearance.

The tooth-like processes in this species are so prominent, that from their similar form, and before I had recognized this peculiar structure in Mr. Springer's specimen also, I at first took them for the triangular cross-pieces, but on closer inspection I found no sutures between the projections and the quadrangular portions of the plates; and as the place of attachment for the triangular pieces is plainly visible, there can be no doubt but that these plates were not preserved in the specimen. Furthermore, as the quadrangular pieces are with slight interruptions found on all the arms of the specimens most beautifully preserved, it seems almost impossible to understand how the triangular pieces could have fallen out, if they had been fastened solidly to the adjoining plates. Supported by the tooth-like projections, and resting against the edges of the quadrangular plates, they were evidently better protected than the outer pieces, and it seems to me their destruction would have involved that of the entire covering. I therefore believe these plates were not firmly attached in the living animal, but merely leaned against each other as well as upon the tooth-like projections, being only attached to the inner edge of the quadrangular plates by muscular or interarticular substance, and that they were, in analogy with similar plates in recent Crinoids, movable. This seems further confirmed by the construction of the plates themselves, and especially by the manner of their attachment. The inner edges of the quadrangular plates (between the projections), being slightly convex, they rested in regular sockets which facilitated their opening in an outward direction. In case these plates, as I can no longer doubt, could be opened or closed, it seems reasonable, that they were open in my specimen when the animal died, or they otherwise would have been preserved.

The position and construction of the inner channel proves most satisfactorily and in analogy with recent Crinoids, that it contained the *food-groove* which conveyed the food through the arm-openings beneath the vault to the oral aperture. The small movable plates are evidently homologous with the "*saumplatten*" of Antedon, and the imbrications of these plates, as well as of the entire covering, seems to hint at the conclusion, that the furrow was always closed when the arms were folded up as in Mr. Springer's specimen; but that on the contrary, as in my specimen, the furrow was open when the arms were spread, and that in this position the animal took in its food.

In describing the covering of the furrow, I have already mentioned the presence of two rows of small pores located at the angles of the triangular pieces. There is nothing to indicate that these pores were sockets of pinnulæ, and if they were, the "saumplatten" could not have opened. From their position I infer they were passages for tentacles connecting with parts of the inner tube. If this is correct, it seems to me, there must have been located within the tube a passage in connection with the ambulacral system, since the tentacles form a part of it. This is evidently the case. In a transverse section of the arm, with the help of a magnifier, I think I have detected within the tube, traces of two passages: *a deep groove* occupying only the median region, and on each side of it *a small canal*, underlying the pores. The condition of the specimen does not enable me to say whether the two side passages connect at the bottom or not, but in either case, they undoubtedly represent *the ambulacral canal*, the food-groove occupying only the median and upper part of the channel.

It is to be regretted that in no instance the upper part of the tubular skeleton has been found in perfect preservation. There has been observed beneath the vault an annular vessel, constructed of plates similar to those of the radiating tubes, with small openings directed toward the radial sides of the specimen, with the alimentary canal passing through the inner space of the ring, but its connection with the surrounding parts was not preserved. The position of the annular organ in the center of radiation leaves but little doubt that it is *the œsophageal ring* or *center of the ambulacral system*. The great similarity in the construction of its plates, the presence of openings corresponding to the direction of the tubes, indicates most strongly that the tubes and the circular organ were connected, and that the ambulacral canal, which I recognized in the lower passage of the arms, communicated with the pores. But, as seen from the casts, there proceeded below the vault from the arm-bases to the center, another series of passages, which passing the region of the annular vessel, unite in the center. I hold these to be a continuation of the food-grooves in the arms, which evidently passing over the top of the circular organ terminated within the central orifice.

The position of the æsophageal ring seems at first sight to be not quite in harmony with recent nature; this organ, which in all Echinoderms with an external mouth, is attached to the inner side of the test, is located in Paleozoic Crinoids at a distance from the vault. However, considering that the aboral vault cannot be homologized with the oral skin of recent Crinoids, and that only the tubular skeleton corresponds to the radiating passages connecting with the peristome, the vault thus forming a mere covering, we shall find the position of the circular organ perfectly harmonious with that of all other Echinoderms.

I have mentioned already that there exists in the arm-groove of *Cyathocrinus*, beneath the tube and at the bottom of the furrow, another canal, as large or larger than the channel of the tube, whose functions are unknown. It was, apparently, through the bottom of the arm-openings, connected with the perivisceral cavity of the calyx and may have served for several offices, containing perhaps also the cœliac canal.

Dr. Schultze, in his "Monograph on the Echinoderms of the Eifel," p. 17, gives a most excellent description of the arm-furrow in *Cupressocrinus*. He found two sets of plates covering the furrow like a roof, and asserts, that the inner pieces could be turned back in the living animal. I had overlooked this in making out my descriptions, but it was pleasing and highly satisfactory to me to find that we both had arrived independently at the same conclusion. The construction of the arm-furrow of *Cupressocrinus* is very similar to *Cyathocrinus*. In a section of the arm of this genus, I readily distinguished, by transmitted light, the food-groove, which has a narrow and deep outline, a canal on both sides of it, and I have but little doubt but that the arm-furrows were similarly constructed in all Palæozoic Crinoids.

3. *The alimentary canal.*

Meek and Worthen publish in the Geological Report of Illinois, vol. v, most excellent descriptions and figures of an organ which occupies the greater part of the visceral cavity of Paleozoic Crinoids; they call it from its position in analogy with other Echinoderms "*the digestive organ.*" It is a large convoluted body, resembling in outer form and outline the shell of a Bulla, with a longer vertical axis, and open at both ends. The upper end is placed below the center of the ventral disc, the lower one directed toward the column, dilated above, contracted below, coinciding with the inner space of the visceral cavity to the walls of which it stands nearly parallel. In some cases it is subcylindrical and slightly truncate at both ends.

The organ is constructed of a great number of very minute pieces or bars with intervening meshes, but its delicate texture is but seldom observed, owing to the presence of incrustations of calcareous or siliceous matter which fill up the meshes, and give to the structure a rather dense appearance.*

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* To these incrustations which are evidently deposits from the water, we owe in a great measure the preservation of these delicate organs, and as they are comparatively thicker in adult specimens, they seem to have accumulated already during the life of the Crinoids, and may have caused in many instances their death.

The convolutions are directed outward from left to right, varying in number from two to four in different species. Judging from external appearance only, the convoluted walls of the organ appear as mere partitions leading to the inner chamber of a bulla-shaped body. This however is not the fact. Examining the so-called walls in some transverse sections, I find them to be coiled, without touching each other at any point, and composed of two distinct partitions, placed side by side and closed at the edges, thus proving that the apparent walls are the coiled organ itself. According to this, the digestive organ consisted of a long flattened canal, rounded at the outer side, widest in the middle, tapering rapidly at both ends to a rather heavy flattened tube, the outer end ascending spirally toward the top of the visceral cavity, making two or more turns, while the inner one, winding in a spiral way around its own axis, passed upward to near the center of the dome.

In a specimen of *Actinocrinus* in which the digestive organ is apparently perfect, though showing the usual rough appearance, I succeeded in removing at one side the two upper convolutions, in such a manner that the detached parts can be replaced or lifted up for investigation. I had here an opportunity to examine the inner or more properly upper end of the alimentary canal (as distinguished from the outer end or terminal part). The top is unfortunately hidden below some inorganic matter, but enough can be seen to prove that it proceeded evidently from a place below the center of the dome. The organ, where it comes into view, is an elongated tube, which passing downward, widens first gradually to near the middle of the visceral cavity, then rapidly until it acquires the width of at least two-thirds of the entire length of the cavity. The upper end in descending spirally turns from right to left, but on becoming wider curves sharply in the opposite direction and the convolutions are now directed from left to right. The outer end also tapering rapidly and forming a flattened tube, ascends the outside spirally from below all the way up to the top, and I am inclined to suppose, proceeded to the proboscis, being probably analogous with the terminal intestine of the Echini, while the upper end communicated with the food-groove.

Such, with slight modifications, was probably the construction of the alimentary canal of all *Actinocrinidæ*, *Platycrinidæ*, etc., but not that of the genus *Ollacrinus*.* I found the alimentary canal partly preserved in *Ollacrinus tuberculosus* Hall, in which it seems to have been composed of the same delicate network, but the organ consists here of a round canal which descends spirally, and contracting gradually, takes at the lower portion of the visceral cavity an upward direction. The upper part of the organ is unfortunately not preserved in this specimen.

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* Figured by Cumberland without generic or specific diagnosis or specific name, London, 1826, in the Appendix to Reliquiæ Conservatæ.

Synon.—*Gilbertsocrinus* Phillips, 1836, Geol. Yorkshire, Pl. II, p. 207. *Goniasteroidocrinus* Lyon & Casseday, Suppl. Geol. Rept., Iowa, p. 70. *Trematrocrinus* Hall, 1860, Suppl. Iowa Geol. Rept., p. 70.

As Cumberland's figure is perfectly correct and easily identified as *Ollacrinus* (*Gilbertsocrinus*) *calcaratus*, his generic name "*Ollacrinus*" must be retained according to the laws of nomenclature.

4. *The anal aperture and the proboscis.*

The anus of Paleozoic Crinoids is placed always within one of the interradial series, which is generally wider than—and often constructed differently from—the others. The aperture is situated either in some part of the calyx itself, or at the top of a long proboscis. It is a most remarkable fact that genera which evidently belong to the same group, even species, apparently of the same genus, for instance *Strotocrinus*, differ so widely in the construction of this organ. Some having a long massive tube, reaching to several inches above the tips of their arms, while others are provided only with a plain lateral opening without any superstructure whatever.

I do not speak at present of the inflated or balloon-shaped proboscis of *Zeacrinus*, *Cœliacrinus*, *Poteriocrinus*, *Heterocrinus* and similar genera, in which this part is more properly called "*the ventral sac*," as it evidently formed a large portion of the visceral cavity. Its great size compared with the lower cup, the presence of large numbers of small pores, and the position of the anal aperture near the bottom instead of at the summit, seems to imply that the anal apparatus occupied in the internal economy of this sac only a limited space. The inflated sac can accordingly not be homologized with the slender, heavy plated tube of *Actinocrinus*. We can only compare its lateral opening, which is generally placed low down near the arm-bases, with the anal aperture of species in which the anus is located in the ventral disc.

In addition to its regular functions, the proboscis of Palæozoic Crinoids may have had the office of expelling the water from the system. This suggestion looks not unreasonable, if we consider that the solid body of the majority of these Crinoids had apparently no other outlet. I found in one instance the proboscis split open longitudinally, and within its inner cavity a well defined narrow tube, filling scarcely one-fourth of the inner space. This tube may have connected with the terminal intestine which I have described above, and the office of the surrounding canal may have been to eject the deoxygenated water from the body. The fact that some Crinoids were provided with a proboscis reaching beyond the region of the arms, and others with no proboscis whatever but simply a lateral opening, is easily explained, for if the rejected matter were emptied between the arms, it must have come constantly again in contact with the arm currents, which is obviated by either plan. This accounts also for the fact that the proboscis of some species of *Eretmocrinus* is constantly turned to one side. The proboscis formed a natural support for the slender arms, for they are found in most specimens leaning closely against it, while in *Dorycrinus* which has no proboscis, the arms appear always clinging to its long, heavy spines, which are evidently not weapons of defence, as some authors have supposed, but merely a support and protection for the arms.

Dr. C. A. White describes in the Boston Journ. of Nat. Hist., vol. vii, No. 4, p. 489, several specimens in which the proboscis diverges at some distance above the ventral disc into two distinct branches. This may be in some instances the result of accidental development, but is more frequently due to an obstruction of the anal canal. I found a specimen of *Batocrinus longirostris* in which close to the vault the proboscis branches into two equally heavy tubes, and there appears immediately above their junction a strong inflation or kind of abscess. In another specimen, a stoppage or disconnection must have occurred within the body, for a second proboscis was formed at the ventral disc, developed here, as in every other instance, within the anal series or posterior side of the Crinoid. In one remarkable specimen a second proboscis breaks forth even at the lower end of the calyx, just above the basal plates. The pressure against these parts must have been enormous, for it caused the destruction of an entire ray, the plates of which are bulging out, forming together with the anal plates, and intermingled with smaller plates, such as ordinarily compose the proboscis of this species, a large elongated cavity with a rather large aperture. All these instances give evidence of a pressure from within, and indicate that the outside opening of Paleozoic Crinoids was solely an ejective organ, and could not have had oral functions. I have already mentioned that the anus is separated from the radial series by deep partitions at the inner surface of the vault, thus excluding any connection with the upper end of the digestive organ. Moreover, the casts of *Actinocrinus* show that the course of the proboscis is directed toward the posterior side, and the development of the abnormal proboscis occurs invariably in the anal series. It is therefore hardly necessary to argue on Dr. White's supposition that the abnormal second proboscis, wherever it occurs, might have served as buccal orifice, as such a theory is unsupported by analogy.

(To be continued.)

ART. XVIII.—*Chemical constitution of Hatchettolite and Samarskite from Mitchell County, North Carolina;* by OSCAR D. ALLEN, Professor of Analytical Chemistry, Sheffield Scientific School. *Contributions from the Sheffield Laboratory.* No. XLVIII.

I. *Hatchettolite.*

IN an article on the Samarskite of Mitchell County, North Carolina, (this Journal, March, 1876), E. S. Dana described a mineral associated with it as possessing the following properties: Specific gravity, 4·794, crystalline form, regular octahedrons with cubical faces, also the planes 3-3, color yellowish brown, luster resinous, blowpipe characters agreeing closely with pyrochlore. At that time I was able to make only a partial qualitative analysis of this mineral with ·25 gram placed at my disposal by E. S. Dana. The result showed the presence of lime, uranium, iron, a trace of magnesia, tantalic and columbic acid, and probably titanic acid.

In an elaborate paper on American columbic acid minerals, published in this Journal (May, 1877), Professor J. Lawrence Smith has also given a description, accompanied by analyses, of this mineral, for which he has proposed the name Hatchettolite.

Having recently obtained from Mr. L. Stadtmüller a specimen of this new mineral, which he received in a lot of Samarskite sent to him from the locality above mentioned, I have analyzed it, hoping to gain some additional facts bearing on its chemical constitution. The specimen was a large, but imperfect crystal. It was broken into small pieces, and afforded twelve grams of material judged sufficiently pure for analysis. Pieces from different parts of the mass gave the specific gravities, 4·77, 4·84, 4·82, 4·90, 4·76. The results obtained are here presented, Nos. I and II, together with one of the analyses of Dr. Smith, No. III.

	(I.)	(II.)	(III.)
Tantalic acid	29·83	29·60	
Columbic acid	34·24	35·94	67·86
Titanic acid	1·61		
Tungstic and stannic acids	·30		·60
Uranium oxide	15·50		15·63
Lime	8·87	8·89	7·09
Yttria and cerium oxides			·86
Iron protoxide	2·19	2·33	2·51
Magnesia	·15		
Potash	trace*		1·21
Soda	1·37		
Water lost by heat	4·49		4·42
Lead	trace		trace
	98·55		100·18

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* Not separated from soda.

A comparison of these numbers leaves no room to doubt that the same mineral was analyzed by Smith and myself. The sum of metallic acids in No. 1 being 65·68, in No. 2, 65·54, in No. 3 (of Smith) 67·86.* For the separation of tantalic and columbic acids the method of Marignac was used, which may be briefly described as follows. The mixed acids, after weighing, are fused with $HKSO_4$, washed with hot water to remove most of the H_2SO_4, dissolved in hot H Fl. One-fourth their weight of $HKFl_2$ is then added. If crystals do not separate on cooling, concentrate to 7 c. c. per gram (of mixed acids) and let cool; K_2TaFl_7 then separates if tantalum is present in the solution. This salt is collected on a weighed filter, washed with cold water till the washings give no longer an orange-colored precipitate with solution of galls. Dry at 100° and weigh; continue the same process with the filtrate and washings, adding new portions of $HKFl_2$. One readily sees when the acicular crystals of K_2TaFl_7 mix themselves with the lamellar crystals of K_2CbOFl_5. Then redissolve the latter and collect the former on a filter. If the weight of both acids is known, Cb_2O_5 may be calculated by difference. On account of the suspected presence of titanic acid in the substance here examined the second crop of crystals of K_2TaFl_7 was redissolved in hot water and recrystallized. No more acicular crystals could be obtained in sufficient quantity to collect. For the same reason the bisulphate fusion of the mixed acids was treated with *cold* water. The filtrate and washing on boiling deposited a light precipitate, which brought into solution and tested with tin gave an unmistakable reaction for titanium. Moreover, after separation of tantalum the columbic and titanic acids remaining in solution were obtained by evaporating with H_2SO_4 and boiling with water and fused with K_2CO_3. Treatment of the fused mass with water left but very little residue, which further examination proved to be mostly potassium titanate.

In analysis No. 1, the two products containing titanic acid, obtained in this way, were fused with $HKSO_4$ which rendered the greater part soluble in cold water. This solution on boiling deposited what was assumed to be titanic acid, after weighing and subjecting to the further tests. It can hardly be expected that a very accurate separation was effected. By boiling ·5 gram of the mineral with H_2SO_4 mixed with a little HFl in a platinum crucible so rapidly as to exclude air decomposition was effected in a few moments. The diluted solution deoxydized an amount of permanganate of potash corresponding in one experiment to 1·90 per cent FeO, in another to 2·20

*** Professor Smith remarks, "I refer to the metallic acids in the analyses in this paper as columbic acid from the fact that the tantalic acid which accompanies it is only in small quantities, and also because none of the methods proposed for separating the two acids have given satisfactory results in my hands."**

per cent. Iron was therefore assumed to exist as protoxide and uranium as UO_2O. A calculation of the relative number of atoms from No. 1 gives the following:

Atomic weights.			
182	Ta	·134	·386
95	Cb	·252	
50	Ti	·020	
U 240	UO_2	·054	·268
	Fe	·030	
	Mg	·004	
	Ca	·158	
	Na_2	·022	
	H_2O		·255
	Sn?	·002	

Disregarding the small amount of tin or tungsten and deducting Ti with $\overset{II}{R}$ sufficient to form with it normal titanate, there remain $\overset{II}{R}$ ·248 $\overset{V}{R}$ ·386 H_2O ·255, whence $\overset{II}{R}:\overset{V}{R}:H_2O=2:3{\cdot}1:2$, a ratio closely approximating to that required by $\overset{II}{R}_2\overset{V}{R}_2 2H_2O$ or $\overset{II}{R}_2\overset{V}{R}_2O_7+2\overset{II}{R}\overset{V}{R}_2O_6+4H_2O$, in which $\overset{II}{R}$ represents one atom of a bivalent basic radical or two of sodium and $\overset{V}{R}$, Ta, or Cb. The investigations of Rammelsberg* lead to the conclusions that three columbates (in which Cb may be replaced by Ta) occur in minerals, viz: $\overset{II}{R}Cb_2O_6$, $\overset{II}{R}_2Cb_2O_7$, and $\overset{II}{R}_3Cb_2O_8$, corresponding to phosphates and arsenates; which, singly or combined with each other, with or without titanates., zirconates, thorates, etc., constitute mineral species. Hatchettolite appears to be composed of the first two with a small quantity of normal titanate.† It it perhaps questionable whether there is any significance in the fact that the amount of water present bears a simple ratio to the other constituents.

Some pieces from one side of the specimen from which material for analysis was selected had the specific gravity from 4·60 to 4·70 per cent and were rejected. They lost by ignition 4·97 per cent. Hatchettolite may have resulted from alteration of a mineral having essentially the same chemical constitution, as well as crystalline form, as pyrochlore, an alteration consisting of hydration and removal of alkaline fluorides.

II. *Samarskite.*

Samarskite from Mitchell Co., according to the analysis of the writer,‡ has the following composition:

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* Jour. Chem. Soc., vol. xxv, p. 189.

† Rammelsberg (Jour. Chem. Soc., vol. xxv, p. 203) supposes that these three compounds may be isomorphous, and that they exist in the isometric crystalline form in pyrochlore.

‡ Dana's Text Book of Mineralogy, p. 340, March, 1877.

		(1)		(2)	Atomic ratio.	
Columbic acid	55·60	37·81	55·80	37·20	·2754	·3592
Tantalic acid		17·79		18·60	·0838	
Stannic acid		----		0·08	·0005	·4430
Yttria		14·52		14·45	·1896	
Cerium oxides*		4·10		4·24	·0382	
Uranium oxide (VO_2O)		12·63		12·46	·0433	
Manganese protoxide		0·80		0·75	·0106	
Iron protoxide		10·60		10·90	·1513	
Lime		----		0·55	·0100	
Water		----		1·12		
				100·35		

These results do not differ materially from the first published analysis of samarskite from the same locality by Miss Ellen H. Swallow, who found 54·96† per cent of metallic acids of the tantalic group, and expressed a wish that some one might undertake their separation.‡ In my analyses, tantalum and columbium were separated by Marignac's method. Water expelled by ignition was collected by a calcium chloride tube. 0·5 gram of the very finely pulverized mineral was completely decomposed by heating with sulphuric acid in a sealed glass tube. The solution, properly diluted, decolorized an amount of potassium permanganate corresponding to 11 per cent of protoxide of iron. A repetition of this experiment confirmed the first result. It may therefore be concluded that no material amount of uranium is present in the lower state of oxidation (UO_2). The relative number of atoms of each element present is calculated from No. 2, uranium being assumed to exist as UO_3 or an oxide (UO_2O) of the bivalent radical UO_2 which it is reasonable to suppose acts as a basic radical with tantalic and columbic acids, as it does with phosphoric and arsenic acids in several natural compounds. $\overset{\text{II}}{R}:\overset{\text{V}}{R}$ is then $4430:3592=1·236:1=4·94:4$ closely approximating $5:4$ required by the formula $\overset{\text{II}}{R}_2\overset{\text{V}}{R}_2O_7+\overset{\text{II}}{R}_3\overset{\text{V}}{R}_2O_8$.

In chemical constitution this samarskite appears to approach Fergusonite being next to this mineral the most basic of the natural columbates and tantalates. The formula of Fergusonite, deduced by Rammelsberg from a large number of analyses, is $\overset{\text{II}}{R}_3(Cb, Ta)_2O_8$.

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* The atomic weight of didymium was used in calculating the atomic ratio. This element is readily shown by spectroscopic examination of a solution. Only a minute quantity of cerium is present, the presence or absence of other elements of the cerium group was not ascertained.

† Dr. Smith's analysis, contained in the paper already cited, gave 55·13 columbic acid.

‡ Proceedings of the Boston Society of Natural History, vol., xvii, 424, 1875. See also this volume, p. 71.

ART. XIX.—*On the relations of the Geology of Vermont to that of Berkshire;* by JAMES D. DANA.

[Continued from page 48.]

IN the preceding part of this paper, the unity of the system of rocks occupying the limestone region of the Green Mountains has been demonstrated by reference to facts connected with the geographical arrangement and stratigraphical relations of the formations. One other well-known feature characterizes the belt from north to south, and requires consideration: namely—

3. THE ABUNDANT OCCURRENCE OF IRON.

The existence of iron in the rocks is known mainly from the beds of limonite along the region. This limonite, as is now well known, was made from the rocks *in place*, and hence it is testimony as to what the original rocks contained and still contain where unaltered. Its beds exist in Vermont at so many places that the geologists of the Vermont Survey represented it on their geological map of the State as a continuous band of limonite. And south of Vermont it occurs more or less in each of the towns over the limestone area, and in some of them in deposits of great depth, the most noted being in Richmond and West Stockbridge, Massachusetts; Salisbury and Sharon, in Connecticut; Hillsdale, Copake, Ancram, North East (near Millerton), Amenia, Dover, and Pawling, in New York. In order that this feature of the region may be appreciated, I mention here the more prominent facts connected with the ore-beds. In a general way, and for special localities, the subject has been often treated. The descriptions given in this place have particular reference to the regional characteristics of the beds in the limestone belt, as illustrated by their mineral nature, distribution, and stratigraphical relations; and they have been drawn mainly from my own observations.

(1.) *The mineral nature of the beds.*

Throughout the great limestone area, from north to south, the ore-beds are alike in the nature of the ore, its mode of aggregation, and its association with yellow ochre and clays. Moreover, in most of the beds to the north as well as south more or less manganese is present with the iron. Manganese ore (chiefly pyrolusite and psilomelane) has been observed in connection with ore-beds of the Vermont limestone area in Bennington, Chittenden, Pittsford, Brandon, Middlebury, Bristol; and the Vermont Report adds, "in the vicinity of most of the beds of limestone in the State." It has been observed also in various ore-beds of Berkshire and New York, though less abundantly than in Vermont. An analysis of ore from the Leet ore-bed, West Stockbridge, by Dr. A. A. Hayes, made in 1845, obtained red oxide of iron 76·18, oxide of manganese 5·04, phosphoric acid 2·36, water 10·80, quartz and gangue 3·40 = 98·78.* At the same time, phosphoric acid is very sparingly present; and there is only a trace of sulphur or none at all. The clay, while generally impure from the presence of iron ochre and other mineral material, is sometimes a white kaolin.†

(2.) *The geological distribution of the beds.*

(1.) The limonite deposits are alike throughout the limestone area in their interrupted occurrence and varying depths—even many miles often intervening between those of workable value, and all depths existing from zero to one hundred and fifty feet or more.

(2.) The ore-beds occur in the vicinity of all the rocks of the limestone area,—the limestone, clay-slate, hydromica slate, mica schist, gneiss and quartzyte. But, from north to south along the limestone area, they most abound where the schist is the hydromica slate, and hardly at all where it is common argillyte. The hydromica slate in Vermont prevails over the eastern half of the area, and, in Berkshire and farther south, over the western half; and accordingly the line of maximum ore-beds does not follow the general course of the limestone area, but is a little oblique to it, having more westing to the south. In Vermont it is with few exceptions not far from the western border of the eastern quartzyte range, as we learn from the Vermont geological map; the few exceptions occur near the center of the area, adjoining small central slate ridges, as in Dorset and on the borders of Wallingford and Tinmouth; and at the south end of the State in Bennington. These last are near the Taconic (or Great Central) slate-belt.

In Berkshire, beds exist sparingly in the eastern portion of the limestone area (as in the gneiss and mica schist region of Tyringham); the chief beds are in its *western* half in Richmond and West Stockbridge, a few miles east of the Taconic range. In Connecticut, they closely adjoin the Taconic range in Salisbury and Sharon; while in New York, they occur on

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*** I am indebted for a copy of this analysis to Mr. J. W. Hoysradt, President of the Company. Mr. Hoysradt states that no later analysis has been made; but he is of the impression that the ore now obtained yields less manganese and phosphoric acid.**

† While limonite (in which the oxide of iron, Fe_2O_3, and the elements of water are in the proportion of 2 to 3) is the principal ore, there is also at Salisbury, as first shown by Prof. G. J. Brush (this Journ., II, xliv, 219, 1867), and probably also at other places, the related ore *turgite* (in which the same ratio is 2 : 1), and a little göthite (in which the ratio is 1 : 1); also occasionally a red ochre, which may be either turgite, or the simple anhydrous oxide Fe_2O_3. Besides the iron and manganese ores, there are also traces of cobalt and zinc.

the *west* of the Taconic range, in the towns of Hillsdale, Copake, and North East, besides along its eastern border in Dover, Amenia and Pawling. The axis of the band of maximum ore-beds appears hence to cross the axis of the limestone area in Bennington, Vermont; and to strike the Taconic range south of West Stockbridge, from which point, beds occur on both sides of the range.

(3.) *The stratigraphical relations of the beds.*

The ore-beds, to the north as well as south, occur near the junction of a stratum of limestone with one of hydromica or mica schist, the beds of both having usually a high dip (generally between 40° and 55°); or they have schist on both sides; and sometimes they are cut through by one or two beds of limestone or schist. Quartzyte often lies along the east side in Vermont; but a stratum of schist usually, if not always, intervenes between the quartzyte and limestone.

This geological relation of the beds was recognized, at localities in Vermont, Berkshire, and Connecticut, more than fifty years since, by the late Prof. Chester Dewey, then Professor of Geology and Mineralogy in Williams College, Williamstown. In the fifth volume of this Journal, 1822, in an article on the ore-bed of Bennington, he says (p. 251)—"It has been remarked that the great bed of ore is not *immediately* connected with any rocks. It seems, however, to be associated with limestone rocks, and the whole to lie between two strata of mica slate. It lies in the same [mountain] range with the ore of Salisbury, Connecticut, and has the same range of mica slate lying on both sides of it." The *in situ* position of the ore-beds is here brought out by Dr. Dewey, and a relation to the limestone is suggested. Two years later, in vol. viii, speaking of the ore-beds of Berkshire, he says (p. 30), that the beds "are near limestone, but on beds of clay." And "as mica-slate is found on both sides of them, they must doubtless be considered as lying in this rock, though the clay indicates that they are a later deposit than the rock itself:" in which the limonite beds are made a part of the mica slate, but not an original part.

The facts at many of the ore-pits of Berkshire and New York, as well as Connecticut, sustain the statements of Professor Dewey. The schist often forms part of the walls of the ore-pits, or stands in ledges near by; and when no rock is to be seen, the clays often show that they are the decomposed schist *in place* by their having its schistose structure, its dip and strike, and also its flexures, all corresponding precisely with the stratification of the rock of the region. The schist makes sometimes the eastern wall, and sometimes the western; and it is also found dividing the ore of the beds. Among the

New York ore-beds the relation of the schist is well exhibited in the Weed ore-pit in the town of Copake, and in the ore-pit, a mile and a half to the west of the village of Pawling.

Limestone strata outcrop near or within many of the pits. In Richmond, Mass., at the Cone ore-pit, a steeply dipping limestone stratum forms part of the northwest side; and at the Cheever ore-pit there is an outcropping bed a few yards to the west, conformable with the slate; at the Leet ore-pit, in West Stockbridge, limestone forms a ledge close by the pit. At the Miles ore-pit, in Copake, a bed of limestone was met with cutting through it, having the strike and dip of the region. The Vermont Geological Report states (p. 820) that a limonite bed in Western Bennington reposes on an impure ferruginous limestone, and it alludes to the similar position of the ore in other beds of the State.

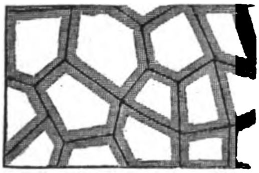
(4.) *The source of the ores and clays.*

Carbonate of iron (spathic iron, or siderite of mineralogy) occurs in masses, in connection with some of the ore-beds; and part of the limestone is ferriferous, that is, either a carbonate of calcium-and-iron, or else, a limestone containing more or less of carbonate of calcium-and-iron. And in consequence of the extremely easy oxidation of the iron of these carbonates, such beds, when air and moisture have access to them, are in all cases undergoing alteration to limonite. In some of the ferriferous limestone manganese replaces part of the iron.

The pure carbonate of iron has been found thus far only in western Berkshire. At the Leet ore-bed, one and a half miles west of the village of West Stockbridge, there projects from the east side of the pit, what is called the "white horse," which is a large ledge of compact light gray spathic iron, of a grayish white color, distinguished as "white ore." It has for many years been quarried and used in the furnace along with the limonite. This "white ore" is so close-grained as to be almost flint-like in aspect, and it evidently owes its preservation from change to this quality, which renders it impervious to water. Wherever there are cracks water and air have entered, and the cracks are widely bordered with limonite. Some pieces have a thin crust of limonite—a quarter to half an inch thick—showing some progress of the alteration even over the harder portions. There are botryoidal prominences of the iron-carbonate in cavities, which seem to be protected from the change by their smooth surface as well as firm texture. This mass of "white ore" is conformable in stratification with the limestone of a hill close by the north edge of the ore-pit; and hence it was probably part of a stratum that has disappeared, over the interval between them, by alteration. I have been informed by Mr. R. Van Buskirk, who is in charge of the mine, that this "white ore" has been taken also from the west side of the pit. There is also an outcrop of limestone in the ore-pit in which some of the layers are changed to limonite, while others above or below are unyielding—the presence of iron in any layers of the limestone (as an iron-calcium carbonate) determining their destruction.

At the Cone ore-pit, one and a half miles north of West Stockbridge, mining is done mostly through shafts; only at the north end is open mining going on so that the structure of the walls can be studied. At this end of the pit, limestone is in view having an eastward dip of 40° to 50°; and while some of the layers are not much altered, others are wholly changed to limonite. At my last visit (in 1875) the work was going on in this stratified material, the limonite portion being selected out for further separation by washing. Several layers had become wholly replaced by pure limonite, and one of those so changed was a yard thick. Some surfaces of the limestone were intersected by cracks, making areas three to six inches across, as represented in fig. 18; each crack having a border of limonite either side, an inch or so wide.

18.



The schist near by—hydromica slate—was in part firm, and in other places turned to soft grayish or yellow clay—an impure kaolin—which was silvery in surface from traces of the original mica of the slate. The quartz veins in the hydromica slate remain of course unchanged, in the ores.

The Cheever ore-bed, in Richmond, has also afforded some massive carbonate of iron, but less abundantly than the Leet ore-bed; and here, as already stated (p. 135), there is a limestone ledge near the pit.

Professor E. Hitchcock mentions the occurrence of massive carbonate of iron in Richmond, in his Report on the Geology of Massachusetts (1841), page 190, and gives an analysis showing that it contains 87·19 per cent of carbonate of iron, 5·21 carbonate of magnesium, 2·46 carbonate of manganese, 1·41 carbonate of calcium, and 2·81 of silica, alumina, etc. =99·08. The particular ore-bed in Richmond affording it is not stated, but it was probably the Leet ore-bed. In the Vermont Geological Report (1868), p. 236, Prof. E. Hitchcock gives an analysis of a dolomite from the vicinity of the Brandon ore-bed which afforded 3·61 per cent of carbonate of iron; and states that east of the bed another limestone was quarried for a flux which contained "10 per cent of iron" [carbonate?].

The limestone has occasionally a little pyrite disseminated through it; and at one place east of the village of Great Barrington, the amount is large. But no one has reported its occurrence in the limestone about the ore-beds, and I have not myself observed it there. There is certainly not much of it.

The hydromica slate of the region contains several iron-bearing minerals: among them, pyrite (FeS_2) sparingly; pyrrhotite (Fe_7S_8) more sparingly; chlorite, often abundant, both to the north and south; garnet, often abundant in Berkshire and farther south; black mica, to the south; staurolite, rather common in Connecticut, in Salisbury and Sharon. In the decomposition of the schist all the minerals present must have contributed to the iron, for the clays contain none of them. It is probable that the schist where in near contact with the limestone also contained the iron-carbonate; but no positive evidence on this point has been obtained.

The beds all show that their formation was not dependent on erosion or transportation; and that the change to limonite required only the free access of air and moisture (with the traces of carbonic acid they ordinarily contain) to the iron-bearing materials. From some of the mines it appears that the best positions for the making of deep beds was off the mouths of valleys, or near slopes that carried down the rains for underground use. An iron-bearing carbonate would suffer rapid destruction under these conditions.

The facts which have been brought forward show that the ore-beds of Berkshire are essentially the same in nature, distribution and position with those of Vermont. The quality of the ore, the occurrence of the beds at intervals, greater or less, along the course of the limestone area, their stratigraphical relations to the limestone and schist, their origin in the oxidation of iron-bearing minerals present in the rock formations, and the concurrent decomposition of the enclosing rock or rocks—these conditions are alike for the whole area, from its northern end in Monkton, where is the most northern of the associated ore-beds, to the south extremity, near Pawling, N. Y., which place also has its large ore-bed. The facts sustain our proposition as to the geological unity of the formations. The fact that the belt of maximum ore-beds crosses obliquely the limestone area,—being near its eastern border to the north in Vermont, and near its western, west of the Taconic range, to the south,—affords additional demonstration of that unity, and suggests a close stratigraphical relation between the eastern and western sides and their formations.

The iron-bearing minerals include an iron-bearing limestone (carbonate of calcium in which iron replaces part of the calcium) both in Vermont and in Berkshire. The simple iron-carbonate has as yet been found only in Berkshire; but its ready oxidation is a sufficient reason for its not being exposed to view even where it is or has been a prominent source of the limonite.

Most of the points in the preceding view with regard to the origin of the limonite have been recognized by different geologists; and yet the view as a whole is not so well understood that the preceding explanations are superfluous. Professor Dewey seems to have nearly reached it, as shown on page 134, and perhaps he did quite. Professor C. U. Shepard, in his Connecticut Geological Report, published in 1837, page 146, refers the limonite to the oxidation *in situ* of the pyrite and other iron-bearing minerals in the mica or hydromica slate; and he remarks that garnet and staurolites are often present in such proportions in the slates of Salisbury and Sharon as to impart to them a highly ferruginous character. Dr. Percival, his associate in the Connecticut survey, held independently the same view.

In the year 1838, Dr. R. M. S. Jackson, of Pennsylvania, as stated, with commendatory remarks, by Prof. J. P. Lesley,* announced the conclusion, after a study of the iron ores of Nittany valley and other valleys in that State, that "the brown-hematite (limonite) ore of the valleys belonged to the stratified limestone beds, and had been set free by chemical and mechanical decomposition"—making the iron to have *existed originally in the limestone as the hydrated oxide.*

Professor Hitchcock, in 1861, in the Vermont Geological Report, after stating that the limestone contained sometimes ten per cent of carbonate of iron, and referring to the occurrence of iron carbonate in the West Stockbridge ore-bed, mentioned in his Massachusetts Report, says "it is obvious that the limestones may have furnished the whole, or a part, of the iron;" but he further adds that it is probable that "the ore was derived from both the rocks [mica slate and limestone], and possibly also in some cases from the quartz rock." But to this right conclusion is added the old error, that the iron had been taken "from the subjacent rocks and re-deposited in connection with clay, sand and gravel."

The different views of other authors might be here presented if this were the place for a full discussion of the subject.

The change of the hard schists to soft clay is one of the most striking facts observed in the ore-beds. But if the iron was derived mostly from iron-bearing carbonates, a powerful agent of change was present in abundance in the carbonic acid set free by the oxidation. This acid is the most prominent source of the destruction of granite and of the reduction of its feldspar to kaolin; and in the schist it would act similarly, robbing the feldspar and mica of their alkalies, the removal of which with the addition of water, makes kaolin or a more or less pure clay. Silicates, like garnet, black mica and chlorite, would yield to the same agent, and so give up their iron for oxidation. Sulphuric acid also would have been concerned in the process wherever any pyrite existed, and have aided in the destruction. But the nearly total absence from the ore of sulphur (seldom over one-tenth of a per cent*) appears to be evidence that pyrite played a very subordinate part in the production of the limonite.

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* **Historical sketch of Geological explorations in Pennsylvania and other States. 200 pp. 8vo. Harrisburg, 1876, p. 81.**

It is a question of interest—Whether the iron was in the state of carbonate when the deposits were originally made by sedimentary action, or, whether in some different state, from which it was converted into carbonate as one of the results of metamorphism. The facts on page 133 under section (2) may bear on this question. Where the truth lies it is not important now to enquire. The schists were originally marine mud beds, while the limestones were clear-sea formations, an era of one condition in that region having been followed by an era of the other. Between any two such eras there appears to have been an epoch of long-continued marshes, and, while it existed, drainage-depositions of iron, in some state of composition, took place over the marshes. And this feature characterized the area from north to south, though with great local differences depending on differences in depth of water and position. If the iron was deposited in those marshes as carbonate, this result was no doubt favored by the excess of carbonic acid in the Lower Silurian atmosphere and waters.

One corollary of importance seems to flow from the facts here considered. It is this: that, in some localities, beneath the richest part of a limonite bed in the direction of the dip, there *may be* iron carbonate of inexhaustible extent, and if so the regions will be good for iron ore long after the limonite beds are exhausted.

(To be continued.)

NOTE.—*Professor Dewey's determination, by chemical means, that the Taconic "talcose slate" ("magnesian slate" of Emmons) is mica slate.*—In a note to page 334 of the last volume of this Journal, the Vermont Geological Report is credited with the first announcement that the "talcose slate" of Western New England is mainly a mica slate in which the mica is a hydrous species; and on page 366 of vol. iv (1872) the analyses published in the Vermont Report are cited. It is due to the late Professor Dewey, who in early life worked in chemistry as well as in geology, mineralogy and botany, to state that in the *first* volume of this Journal, published in 1819, in an article on the geology of the vicinity of Williamstown, Mass. (Northwestern Berkshire), he observes that the rock of the Taconic range is mainly a "*very fine-grained mica slate*—a rock which had been called 'soapstone slate,' and appeared to be *talcose;*" "but," he adds: "I have been able to detect but a very minute quantity of magnesia in any specimens I have tried, though I obtained a considerable proportion of alumina."

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* Analyses of the same ores, from similar positions, in Pennsylvania in Frazer's Geological Report, Harrisburg, 1876.

In a later article (vol. viii, p. 8, 1824) he says: "The Taconic Mountain is a huge mass of mica slate." He also uses in the same article the term "talco-micaceous slate" for some portions of the rock, but still holds to the result of his chemical trial that the amount of talc was very small, and that it was strictly mica slate.

ART. XX.—*A proposed new method in Solar Spectrum Analysis;*[*] by S. P. LANGLEY.

No observation of modern Physical Astronomy is more striking in its conception, than that which attempts to determine the motion of a celestial body, by the altered wave-length of its light, and none has attracted more general attention. It is popularly understood, I think, that the proper motion of certain stars in the line of sight, has been thus completely demonstrated, but those particularly engaged in such studies know how far astronomers have till very lately been from the certainty attributed to them. Only last April, Father Secchi presented a communication to the Comptes Rendus[†] in which he recalled the denial on theoretical grounds, by Van der Willigen, of the possibility of any such observation, pointed out the extreme danger of instrumental error in such spectroscopic work, and gave experiments of his own, to show that its causes were so numerous and so subtle that it was difficult to be certain of any result.

Without discussing the replies, which aim to show that lately precautions have been taken which it may be hoped are effective, it may be observed that there is another mode of investigating the reality of the phenomena, not liable to as many difficulties as in the case of the stars, though presenting a formidable one of its own. I mean, of course, the observation of the different wave-lengths of light coming from the east and west limbs of the sun, which, owing to that body's rotation on its axis, have equatorial velocities that together make up nearly two and one-half English miles a second. This speed, enormous in itself, is most insignificant compared with the velocity of light, and this relative smallness constitutes the difficulty in attempting the solution of the problem by means of the sun, for the whole displacement due to it, is (as Professor Young has remarked in illustration), but one-seventy-seventh of the distance between the D lines, or between one-twelfth and one-thirteenth of one division of Angström's scale. Zöllner, Secchi and Hastings have believed that they, nevertheless, detected a change in the refrangibility of the light, and Vogel[*] using Zöllner's reversion spectroscope obtained a displacement of from ·08 to 0·15 of one of Angström's units. In August last, Professor Young gave the results of his own measurements with one of Mr. Rutherfurd's gratings, showing an equatorial velocity of 1·^{m}42. Professor Young was unable to find any displacement of the atmospheric lines. This last research[†] being much more systematic than its predecessors, and given in satisfactory detail, has turned the weight of scientific opinion in favor of the view, that the change due to motion of the luminous body is fairly proven. It can hardly, however, be deemed superfluous to still offer upon so important a question, the results of an independent method of measurement, and one which renders errors from instrumental displacement, on the danger of which so much stress has been deservedly laid, in the sense in which the word is here used, not only unlikely but impossible.

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[*] Communicated to the meeting of the National Academy, held in Washington, April, 1877.

[†] C. R., tome lxxxii, pp. 761–812.

In the course of a research upon the selective absorption of the solar atmosphere, I arranged in 1875, means for comparing homogeneous lights from different parts of the disc. The apparatus was too complex for description here, but it consisted essentially, in the provision of two pair of right-angled prisms of total reflection, so disposed in connection with a spectroscope, that the spectra could be formed side by side, of light from different parts of the sun, and of a photometric apparatus by which the relative intensity of the lights at different parts of these spectra could be compared. The results of this research, with an improved form of the instrument, will I hope be soon ready for publication. It was not intended, primarily, for the comparison of individual spectral lines, for which purpose optical arrangements, not very essentially different, had already been used by Lockyer, Hastings and perhaps others, but the investigation of Professor Young suggested to me another and cognate method of testing the principle of Doppler, to which this apparatus is especially applicable. The theory of the proposed method is very simple. Let two spectra be formed side by side, the one of light from one edge of the sun, the other of light from a point 180° distant. The instrument being in adjustment, if these points be in the neighborhood of the solar poles which are relatively at rest, all the lines will be continuous in both spectra. But if the instrument is rotated till the light comes from points on the eastern and western sides of the sun, which are in relative motion, not only will the solar lines be discontinuous, in the two spectra; as though the one receiving light from the advancing or eastern side had been slid past its neighbor toward the violet; but any mal-adjustments of the instrument, which simulate this effect, can be with certainty detected by a means to be shortly described. The actual quantity by which we may anticipate from theory that the spectra are displaced, is, as has been observed, extremely small, and to produce the desired result we need not only very great dispersion in the spectroscope, but very delicate workmanship in the cutting and mounting of the prisms which are to bring the light to the slit, and in general it will be evident that more than common skill is to be desired of the instrument maker.

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[*] Beobachtungen auf der Sternwache zu Borhkamp.

[†] American Journal of Science and Arts, vol. xii, Nov., 1876.

I wish to acknowledge the obligations I am under in these respects to Mr. F. Walther, of Philadelphia, the optician, and to Mr. William Grunow, the maker, of New York. Not to dwell on those difficulties of detail which always come between the conception and its embodiment in practice, I may say that more than six months have passed in experiment and modification till the instrument has attained its present form, in which I have been finally able within the past few days to see my anticipations justified. That it has been possible to me to undertake this research at all at present, is due to Mr. Rutherfurd, who has given me choice specimens of his gratings, which are so generally known and valued, that it is unnecessary that I should describe them.

It is desirable that a very clear mental picture should be present to the observer, of the *amount* of displacement he is to expect, for though it is well that he should be ignorant, if possible, of the anticipated direction, this knowledge of the amount will prevent him at the outset from confusing apparent displacements due to mal-adjustment of the instrument with those to which his attention should be directed.* I have taken advantage of a table prepared by Professor Pickering, showing the results of different instruments on the fine lines of the E group, to compare mine with them, and I observe that I can discriminate more, and more delicate lines, with either the 8,000 or 17,000 line grating than observers have been able to do with the most powerful spectroscopes of the common construction. Where Angström, using a grating of Nobert's, has delineated twelve lines, the grating supplied me by Mr. Rutherfurd shows thirty-one, and one of these pairs, though separated by but distances of one-sixth of a unit of Angström's scale, is yet clearly divided. The displacement to be expected from the solar rotation, under favorable circumstances, is about one-half of this, and hence if it exist, it is clearly within the power of the instrument to exhibit, since the two spectra are formed in juxtaposition as nice as that of a vernier plate to its circle, a circumstance under which, as every one knows, the eye judges of the continuity of lines with the most accuracy.

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* The following method of statement appears to present material for such a mental picture. In the 3d spectrum of the 17280 line grating the D lines, viewed under the magnifying power most favorable in my instrument to clear vision, appear like two sharply-defined parallel lines $\frac{1}{8}$ inch apart viewed by the naked eye at the distance of 10 inches. One of the units of Angström's scale appears to fill rather more than $\frac{1}{60}$ inch at the same distance. The displacement here due to rotation is as is remarked rather more than $\frac{1}{12}$ or ·08 of a unit, or, referred to the distance of distinct vision, very near $\frac{1}{500}$ of an inch. It is known that we can with the naked eye distinguish $\frac{1}{3000}$ of an inch or less, in the form of discontinuity of two lines on a vernier plate, which is essentially our present case. Owing to defective light and other causes, we cannot do quite this on the sun, as yet, but can still count on detecting by this method a discrepancy of somewhat less than ·03 units, which again is less than half the amount in question.

The instrument itself consists of the grating, with a collimating and observing telescope, each of one and one-quarter inch aperture and fourteen and one-half inches focus, with positive eye-pieces magnifying from ten to thirty times. The slit is constructed so that its jaws are bevelled to knife-edges, where they meet, at the outer surface, and these owing to the excellent workmanship, still close so as to admit no light when held up against the sun. Over this slit, with their bases almost in contact with it, and their united edges crossing it at right angles, are the first pair of reflecting prisms. They are cut from the same piece of glass, and so fitted that their junction-line shows no more in the spectrum than a particle of dust, and in fact, the division between the two spectra is with difficulty distinguishable from the ordinary dust lines. The other two prisms slide independently on ways, with verniers reading to thousandths of an inch, permitting them to be put in any part of a solar image of from one and one-half inch, to five inches in diameter. Over them is a hood, carrying a screen, which receives the image projected by the equatorial telescope. This focal image is nearly one and three-quarters inches in diameter, and any two selected portions of it pass through adjustable apertures in the screen. By the construction of the instrument they are equally distant from the optical axis, and in every other optical condition, as far as possible, similar, except as they may differ at their origin in the sun itself. It shows the difficulties of the method of research successfully employed by Mr. Huggins, and at Greenwich, that when the instrument is turned directly on the sun (i. e. so that each spectrum receives light from all parts of the sun's disc), the two sets of spectral lines will not ordinarily be continuous. Theoretically they should be, practically, we find they are not, owing to numerous latent causes of disturbance. A touch on the prisms, a movement of the slit, an adjustment of the eye-piece, will ordinarily disturb one spectrum relatively to the other, by a minute amount. But the whole change we are seeking is of a minuter order still; how then, can we discriminate it with certainty? In our ability to do this lies the advantage of the method I describe, which, granting sufficient dispersive power, makes impossible the instrumental error that has been dwelt on by Secchi and others with justice, as shaking confidence in the result. To see how we are authorized to use this word "impossible," let us bear in mind that the solar spectrum consists of two distinct kinds of lines, one caused by absorption in the solar, the other by absorption in the terrestrial atmosphere. These latter being formed by light from all parts of the sun are independent of its rotation.

The prisms are adjusted, till, on looking on the sun directly, the lines are all continuous in both spectra, then the instrument is put in the telescope and the slit placed at such a position-angle that the light in spectrum A comes from the vicinity of the north solar pole, that in spectrum B from the south. On looking in, we see a very long and narrow spectrum, filled with dark lines and exhibiting the chromospheric lines on both sides. It is divided by what appears to be a fine dust line, in two exactly corresponding parts, and is in reality two distinct spectra, as we see by the opposed chromosphere lines, but as the sources of light for both spectra are relatively at rest, all the dark lines are still continuous. But now (without disturbing any adjustment), revolve the whole 90° about the optical axis passing through the center of the solar image, so that spectrum A is formed by light from the eastern or advancing edge of the sun; spectrum B by light from the western or retreating one. A curious change has taken place. By a very minute but perceptible quantity, spectrum A appears to have been slid past its neighbor, toward the violet end, so that every solar line in the first is "notched" at its junction with the second, while at the same time, the telluric lines are as unaltered as the fixed lines of a micrometer web would be, by moving a scale about in the field. The effect is the same as though the spectra were tangible things, like two engine-divided scales, whose numerous delicate divisions (represented by the solar lines), were all in exact juxtaposition a moment before, and are all now just perceptibly displaced, as when a vernier plate is moved till a coincidence is made at a new stroke on the limb.

Moving the instrument 90° more, we come again into the axial line of the sun, and the coincidence should return: with still 90° more we are again in the equator, but now spectrum A is formed by light from the western edge, and this time it is moved the other way, as if it were a scale which had been slid by a very slight but distinctly perceptible amount toward the *red* end; while still the telluric lines retain their continuity, assuring us that no mal-adjustment has occurred.

It will be admitted that this change is, if real, excellent experimental evidence that the wave length is virtually different in light from the eastern and western limbs, as theory predicts. For, granting that the instrument is mal-adjusted in any unknown way or degree, any *instrumental* cause will affect solar and telluric lines alike, and we may in fact defy ingenuity to suggest an error of adjustment, which will modify one and not the other.

For the sake of clearness, I have assumed that we start with all the lines continuous in both spectra; in practice this condition is not easily assured: commonly some lurking error, will, without especial pains, cause them to appear broken upon a fixed source of light; but we disregard this, and consider, as we bring the instrument into new positions, only the *difference* of displacement of the solar and telluric lines. The simultaneous observations of this difference, in each of two spectra, is the essential condition relied on, not only in theory but in actual work.

It will be remembered that many lines in the spectrum are only seen when the sun is low. These are clearly due to absorption in our atmosphere. Many thousands, as we know, are due to absorption in the sun's atmosphere. There remains a large number of lines not coincident with any we produce at the electrodes of our battery, and always present in the spectrum. Of these we do know that they are either caused by the sun's atmosphere or ours, without always knowing which, for these can only be inferred to be telluric from their growing stronger as the sun sets,* and this, though easily determined in the case of a single line, becomes a task of great labor where we deal with thousands. It is evident, however, that after having used known telluric lines to determine the fact that the refrangibility of solar lines only is altered, we can reverse the process, and classify unhesitatingly hereafter, all lines as telluric which are unaffected by the changes that compel others to betray their solar origin. To merely see these two spectra with clearness, then, is to be enabled to pick out the telluric lines from the others, as though they were mapped before us. They are mapped in fact, and it becomes, under the proper conditions, a matter of simple inspection to determine them.

I hope then, it will not seem too assuming a title, if I speak of this as a new method in solar spectral analysis.

I have only to add, that in all my trials of this method, I have constantly so arranged each experiment, that I remained in intentional ignorance as to which spectrum came from the eastern, and which from the western limb, until I had determined the point by the different behavior of these solar and terrestrial lines, which I have been able to do thus far correctly in every instance. I believe, in fact, that the effect under proper conditions is so marked that the observer hereafter need not take pains to guard against the unconscious bias of his measurement toward a desired result. I have, in these preliminary experiments, however, thought it necessary to take precautions that no such prepossession, if it existed, might influence me unawares.

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* Or by experiment on artificial lights viewed through intervening atmospheres.

I ought to add that the proposed method is considerably limited, not only by the need of very powerful instruments (for these can be supplied), but by the need of very good observing weather, which unfortunately we have not at command when we want it.

Useful tests of the desired condition are the duplication of such lines as 1529 of Kirchoff's scale, and the more celebrated "1474," known as a close double since Professor Young's duplication of it last year.

I have not yet made any measurements of the displacement by this method, which appears to me as thus far described to be less adapted to quantitative results than that already employed by Professor Young, but capable by the use of the micrometer of giving exact numerical data. I ought to add, however, that Professor Rood, of Columbia College, has offered the valuable suggestion, that by the use of a double refracting prism, we can cause the spectra to overlap, thus not only overcoming some mechanical difficulties which I have not enlarged on, but obtaining at little trouble all the advantage of micrometric measurement. I regret that the instrument reached me so late that I have not yet been able to give a trial to this, from which I hope excellent results. Nor have I been able to introduce photography with other contemplated improvements, such as the simultaneous use of both right and left spectra of the same order, thus doubling the displacement; and the use of three reflections instead of two, on each ray before it reaches the slit, thus inverting the portion of each limb under examination, and bringing the very edges of the sun into juxtaposition, instead of a portion somewhat within the edge, as at present.

I have only to add in conclusion, that while the instruments used have been principally those of the Allegheny Observatory, to which institution my services belong, I should have been unable to carry out this research without certain indispensable adjuncts, the expense of which has been defrayed from an appropriation placed at my disposal by the trustees of the Bache fund.

Allegheny Observatory, April 14, 1877.

ART. XXI.—*Note on the Exactitude of the French Normal Fork; a Reply to the paper of Mr. A. J. Ellis;* by RUDOLPH KOENIG, Ph.D.—[In a letter to the Editors.]

AN attack, as strange as it was unexpected, has just been made in England upon the exactitude of the official French fork. Mr. Alexander J. Ellis, having found that the notes of a tonometer, composed of sixty-five harmonium reeds, constructed by Mr. Appunn, do not agree with this fork, has considered himself entitled to assert, in a paper published in the Journal of the Society of Arts (May 25, 1877) and in Nature (May 31, 1877) that the normal French fork La_3 gives, not 870 single vibrations, as has been hitherto supposed, but 878 single vibrations. Mr. Ellis, having established the further fact that the forks constructed by me are in perfect accord with the French La_3, does not hesitate to affirm that all these forks, including those even of my large tonometer, which he has probably never seen, and in any event has never examined, are necessarily inexact. Not having at my disposal the instrument used by Mr. Ellis, I confess that I find myself under some embarrassment in stating at once by what error of construction this instrument, in the hands of Mr. Ellis, has given results so extraordinary. Fortunately, I can refer to a letter from M. Helmholtz addressed to Mr. Appunn and published by the latter himself in a paper on the acoustic theories of M. Helmholtz. This letter speaks of an instrument of exactly the same character, and made by the same maker, and sufficiently explains the surprising discoveries of Mr. Ellis. "I have examined your tonometer several times," writes M. Helmholtz to Mr. Appunn, "and I am astonished at the constancy of its indications. I would not have believed that reeds could give sounds so constant as those given by your apparatus, thanks to your method of regulating the current of air. The instrument, it is true, varies a little with the temperature, as do also forks; and hence it can be used for determining the absolute number of vibrations, only when one can work in a room heated by a stove. By the aid of an astronomical chronometer, I have counted the beats, and believe that your seconds pendulum must have been slightly inexact, because, though the number of beats agree very well among themselves, the absolute number obtained is not 240 but 237 to the minute. The temperature, which was rather low during my experiments, may count for something; but even this influence may be eliminated by counting the beats to the end of a major third, which took me a quarter of an hour. In this way I have found for my Paris fork 435·01 vibrations, which agrees to the $\frac{1}{40000}$ nearly with the official number, 435 vibrations."

This letter proves that the entire number of beats in the octave of the tonometer tested by M. Helmholtz was $\frac{237}{60} \times 64 = 252{\cdot}8$, and that its fundamental note was 505·6 single vibrations instead of 512. On comparing this note of 505·6 single vibrations with a fork giving actually 512 single vibrations, Mr. Ellis would find the latter to be 6·4 single vibrations more acute and, without doubt, would consider it as giving 518·4 single vibrations. Now for my forks giving 512 single vibrations he has found 516·7 only, with the tonometer which he used. Whence it would seem that the fundamental note of this latter instrument had become more nearly exact than that of the tonometer examined by M. Helmholtz, since the number of its vibrations is 507·3. This note, however, still remains quite distant from its true value.

The fact that M. Helmholtz succeeded, with an instrument of this sort (and one too, even less perfect than that used by Mr. Ellis) in finding the number of vibrations of the official French fork to be exact, by first determining the correction needed for his instrument, is evidence that Mr. Ellis has neglected to determine a similar correction required for his tonometer. He has too hastily declared that these small tonometers with harmonium reeds are the most perfect and the most exact in existence. It would certainly have been much better if he had first given himself a little practice in the manipulation of acoustic instruments, before having treated so slightingly the results obtained by Lissajous, by Despretz, by Helmholtz, by Mayer, etc., etc., and before seeking to throw discredit upon the labors of a *constructeur* who had no reason to expect so unjustifiable an attack.

26 Rue de Pontoise, Paris, June 5th, 1877.

[NOTE.—In response to our request, Professor A. M. Mayer has furnished us with the following statement concerning the absolute number of vibrations of Koenig's forks. "During the months of March, April and May of 1876, I made many determinations of the number of vibrations of Koenig's UT_3 fork and found that it gave 255·96 complete vibrations in one second at a temperature of 60° Fahr. The following are the separate determinations of that series of which the above number is the mean: (1) 255·95, (2) 255·97, (3) 255·90, (4) 255·92, (5) 256·02, (6) 256·02. The fork's vibratory period is accelerated or diminished $\frac{1}{22000}$ part by a difference of temperature of ± 1° Fahr."—EDS.]

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

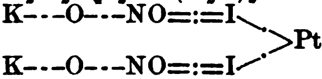
1. *On the Heat of Combustion of Oxygen and Hydrogen in closed vessels.*—THAN has modified the ice calorimeter of Bunsen so as to render it available for determining the heat of chemical action. As a first result with the new instrument—the exploding tube of which he calls a heat-eudiometer—he has obtained accurate determinations of the heat of combustion, in closed vessels, of electrolytic gas. Since, hitherto, according to him, this term has not been defined with sufficient exactness, Than uses "heat of

combustion," or more generally "total difference of energy" of a mixture of oxygen and hydrogen, as expressing that quantity of actual energy which is evolved when the gas at 0° and 760 mm. is completely converted, in a closed vessel into liquid water at 0°. As a mean of five experiments, the heat of combustion found was 2·02930 gram-calories, with a probable error of 0·0018. That is, one cubic centimeter of electrolytic gas at 0° and 760 mm. on burning to liquid water in a closed vessel, evolves 2·0293 heat units. Or, taking the atom of hydrogen as unity, a gram of hydrogen at 0° and 760 mm. uniting with the necessary quantity of oxygen in a closed vessel, and forming liquid water at 0°, produces 33·982 units of heat (gram-calories); a close agreement with the number obtained by Andrews, 33·970.—*Ber. Berl. Chem. Ges.*, x, 947, May, 1877. G. F. B.

2. *On Vapor volumes and Avogadro's Law.*—The law of Avogadro asserts that equal volumes of all substances in the gaseous state, contain the same number of molecules; from which it follows that the molecules of all bodies in the gaseous state are of the same size. Hence calling the volume of the hydrogen molecule 2, the volume of all other molecules will also be 2. While the great majority of volatile bodies conform to this law, there are some whose molecular volumes are apparently represented by 4, 6, or 8. Such bodies are phosphoric chloride, ammonium chloride, ammonium sulphydrate, chloral hydrate, etc. While those chemists who deny the universality of Avogadro's law, maintain that these bodies have actually the molecular volumes given above, those who assert this universality claim that the true molecular volume of these substances is two, as it should be, but that dissociation takes place at the temperature of the experiments, yielding two or more bodies, the molecule of each of which has a volume of two. TROOST has submitted this point, in the case of chloral hydrate, to the test of experiment, in a very ingenious way, by introducing into the vapor of this body, a salt containing water, whose dissociation-tension is, as nearly as possible, equal to that of the aqueous vapor of the chloral hydrate. If the vapor of the chloral hydrate suffers dissociation and consists of equal volumes of chloral vapor and of aqueous vapor, then the salt introduced will give up no water; i. e., the vapor-volume will remain constant. But if chloral hydrate is volatile as such, its vapor is free from water and on introducing the salt it will give up water and the volume will increase till the dissociation-tension is reached. The salt chosen was potassium oxalate, $K_2C_2O_4+H_2O$, whose dissociation-tension at 78° is 53 mm. and at 100° 182 mm. The experiments were conducted in Hofmann's vapor density apparatus, in both alcohol vapor and steam. In both cases the result was the same; the volume increased on introduction of the oxalate. Hence Troost asserts that chloral hydrate is volatile without decomposition.—*Ber. Berl. Chem. Ges.*, x, 899, May, 1877. G. F. B.

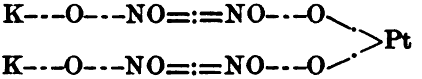
3. *On Plato-diiodo-dinitrosyl and Triplato-octonitrosylic acid.*—By the action of an alcoholic solution of iodine upon potassium

or barium platonitrite, NILSON has obtained a new class of bodies which he calls platoiodnitrites. The mixture, which is at first dark reddish brown, becomes, on heating to 30° to 40°, clear amber-yellow, evolving abundance of gas, in which the characteristic odor of aldehyde is perceivable, and depositing on cooling the platoiodnitrite in crystals. The potassium salt forms large brilliant four-sided amber-yellow prisms, having the formula $K_2N_2O_4I_2Pt\,.\,(H_2O)_2$. Nilson assigns to it the rational formula



$$\left.\begin{array}{l}K{-}{-}{-}O{-}{-}{-}NO{=}{:}{=}I\\K{-}{-}{-}O{-}{-}{-}NO{=}{:}{=}I\end{array}\right>Pt,$$

the relation of this body to the platonitrite



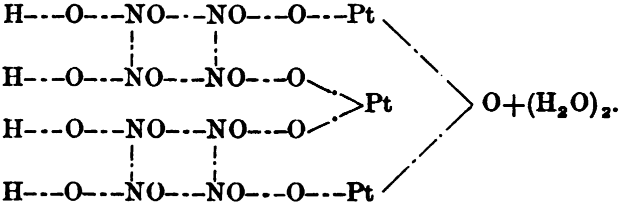
$$\left.\begin{array}{l}K{-}{-}{-}O{-}{-}{-}NO{=}{:}{=}NO{-}{-}{-}O\\K{-}{-}{-}O{-}{-}{-}NO{=}{:}{=}NO{-}{-}{-}O\end{array}\right>Pt$$

being very simple. The reaction he represents thus:—

$$K_2(NO_2)_4Pt+I_2+(C_2H_6O)_3=K_2N_2O_4I_2Pt+C_2H_4O+(C_2H_5ONO)_2+(H_2O)_2.$$

The radical he names plato-diiodo-dinitrosyl.

Nilson has described also a new platonitrosylic acid, obtained while endeavoring to produce platotetranitrosylic acid by the method of Lang. For this purpose barium platonitrite was decomposed by sulphuric acid in the cold, and the solution was evaporated in a vacuum over sulphuric acid. At first red needles were deposited, corresponding to the acid of Lang; but on carrying the solution to dryness, a brownish-green brilliant residue remained, which was easily soluble in water, was strongly acid, was permanent at 100°, and which after drying over sulphuric acid, had the composition $H_4(NO_2)_8Pt_3O\,.\,(H_2O)_2$. Hence the unstable tetra acid, evolving one-third its nitrogen as nitrous acid, forms a remarkably permanent octo acid, the potassium salt of which is well crystallized. The author calls it triplato-octonitrosylic acid and assigns to it the rational formula:—



$$\left.\begin{array}{l}H{-}{-}{-}O{-}{-}{-}NO{-}{-}{-}NO{-}{-}{-}O{-}{-}{-}Pt\\ \left.\begin{array}{l}H{-}{-}{-}O{-}{-}{-}NO{-}{-}{-}NO{-}{-}{-}O\\H{-}{-}{-}O{-}{-}{-}NO{-}{-}{-}NO{-}{-}{-}O\end{array}\right>Pt\\H{-}{-}{-}O{-}{-}{-}NO{-}{-}{-}NO{-}{-}{-}O{-}{-}{-}Pt\end{array}\right>O+(H_2O)_2.$$

—*Ber. Berl. Chem. Ges.*, x, 930, 934, May, 1877. G. F. B.

4. *On the Action of Bromine upon Pyrotartaric Acid.*—BOURGOIN has studied the action of bromine upon pyrotartaric acid, prepared as usual by the distillation of tartaric acid. For this purpose 6·5 grams were heated with 10 c.c. of bromine and 50 c.c. of water in a sealed tube to 130° or 132° for thirty-six hours, or to 152° for fifteen hours. On opening the tubes carbon dioxide was abundantly evolved, and the tube contained a dense liquid upon which rested an aqueous solution of hydrobromic acid. The heavy liquid, after washing with dilute potassium hydrate solution, was colorless and transparent, having an ethereal camphor-like odor,

irritating to the eyes, a sharp very sweet taste, a density of 2·93, and boiling about 200°, undergoing partial decomposition. On analysis it gave the formula $C_2H_2Br_4$. As it readily solidifies at −17°, it is thereby distinguished from acetylene tetrabromide, which remains liquid at −20°. From its reactions, the author regards it as tribrom-ethylene hydrobromate (or its equivalent dibrom-ethylene dibromide,) which solidifies in a freezing mixture and resembles it closely in other particulars. The third body known which has the formula $C_2H_2Br_4$, is tetrabrom-ethylene hydride, a crystalline body melting at 54·5°. The use of bromine in distinguishing the isomeric forms of pyrotartaric acid, is evident. —*Bull. Soc. Ch.*, II, xxvii, 395, May, 1877. G. F. B.

5. *On the Polybasic acids obtained by the action of Carbon dioxide on Phenol.*—The interesting synthesis of orthoxybenzoic (salicylic) and paraoxybenzoic acids by the action of carbon dioxide upon sodium-phenol and potassium-phenol, discovered by Kolbe, and the further discovery by OST, that a second and a third carboxyl group could be in this way introduced into phenol, forming respectively a phenol-dicarbonic and a phenol-tricarbonic acid, has led the latter chemist to study carefully the conditions of the reactions. For the tricarbonic acid, the process is conducted as for salicylic acid, the mixture being finally more strongly heated —to about 360°—until phenol ceases to come over. The purification is accomplished by converting the acid into barium salt, and then decomposing this by a large excess of hot hydrochloric acid; the acid separates in crystals on cooling. From 650 grams phenol, converted into sodium-phenol and heated to 270° for thirty-two hours (when 330 grams of phenol came over) and then for fourteen hours more with a gradually increasing temperature (during which 110 grams more of phenol distilled over), 20 grams phenol-tricarbonic acid were obtained. The dicarbonic acid is best obtained by using a mixture of three molecules of sodium-phenol and one of potassium-phenol, and heating to 320°. By reason of its insolubility in water, the acid is easily purified. From 50 grams phenol, 10 to 12 grams of pure phenol-dicarbonic acid were obtained, and 32 grams of phenol were recovered. Its formation from salicylic (orthoxybenzoic) acid and its conversion into paraoxybenzoic acid on heating, prove that the two carboxyls occupy the ortho and the para positions. As to the tricarbonic acid, Ost converted it into the chlor-acid by the action of phosphoric chloride, and then reduced this by sodium amalgam; thus obtaining trimesinic acid $C_6H_3\left\{\begin{matrix}COOH\\COOH\\COOH\end{matrix}\right.$ identical with that obtained from mesitylene by Fittig. The phenol-tricarbonic acid is therefore oxytrimesinic acid. No further introduction of carboxyl into phenol was possible, the meta derivatives not being obtainable in this way; a fact true also of the nitro-derivatives.—*J. pr. Ch.*, II, xv, 301, April, 1877. G. F. B.

6. *On the Relation of Cystin to Sulphates in the Urine.*—NIEMANN has examined a case of cystinurea and has sought to

determine the quantitative relation between cystin and other constituents of the urine, in this disease. The most noteworthy fact observed was that the per cent of cystin stood to that of the sulphuric acid as 1 : 3·89, and that the two varied together. The quantity of uric acid was diminished, but that of the urea was not sensibly affected. The patient excreted from 0·4234 to 0·595 gram cystin per day.—*Liebig's Ann.*, clxxxvii, 101, May, 1877.

G. F. B.

7. *On Gauss's Theory of Capillarity.*—The virtual work of the molecular forces engaged in the phenomenon of Capillarity is divided, according to Gauss, into: 1, that which arises from the force of gravity; 2, that which arises from the forces between the particles of the fluid; and 3, that which arises from the forces between the fluid particles and the surrounding solid bodies. The contact line between different bodies is made apparent when the complicated integrals are reduced to simpler forms. Lippman separates a quantity from the general expression. This quantity is connected with the variation in the contact line. Lippman believes that he has made this included connection "for the first time" noticeable. He discusses the changed equations of Gauss which he has thus divided into two parts. By a consideration of the facts that the volume variation of solids and in compressible fluid bodies = 0, and that by the shifting of absolute movable particles of a homogeneous fluid without volume variation, no work is done—the original equations can be simplified. Lippman finally shows why we cannot assume that the rise of a liquid in a capillary column depends upon the attraction between the fluid and the unmoistened parts of the walls of the containing vessel.—*Beiblätter, Pogg. Ann.*, vol. i, No. 5, p. 275. J. T.

8. *Influence of Light upon the Electrical resistance of Metals.*—Dr. R. BÖRNSTEIN, Assistant in the Physical Institute of Heidelberg University, claims that: "The property of experiencing a diminished electrical resistance under the influence of luminous rays is not confined to the metalloids selenium and tellurium, but belongs also to platinum, gold and silver, and in all probability to metals in general. The electrical current diminishes both the conductivity and also the sensitiveness to light of its conductor; and both of these, after cessation of the current, gradually acquire their former value.—*Phil. Mag. Supplement*, June, 1877, p. 1.

J. T.

9. *Chemical and Physical Researches;* by THOMAS GRAHAM. Collected and printed for presentation only. Preface and Analytical Contents, by Dr. R. ANGUS SMITH. Edinburgh, 1876.—What Horace wrote of his own works

> "Exegi monumentum ære perennius,"

is equally true of the product of all literary and scientific labor of the highest class, and no more worthy tribute can be paid to intellectual greatness than by carefully cherishing that monument, which the noble intellect during this earthly life erects to itself.

Such a recognition, though long delayed, the French Government bestowed both on La Place and on Lavoisier, by publishing magnificent editions of their works. A similar debt of gratitude the American Academy of Arts and Sciences has paid to Rumford; but we do not hesitate to say that the elegant volume before us, in which his two friends,—James Young and R. Angus Smith,—have embodied the "Chemical and Physical Researches of Thomas Graham," is the noblest tribute of all. To the scientific contemporaries of Graham, among whom it has been widely distributed, this volume is the most worthy memorial possible of the successful student of nature whom all honored, and of the man whom all who approached him loved. His modesty of character was in striking contrast with the self-assertion of the Roman poet who could write the famous verse we have quoted above; but no friend of Graham can doubt that this literary tribute would be far more grateful to him than the bronze statue which adorns his native city. Bronze can add no luster to intellectual greatness, and however much it may swell the false glory of the living, to the eyes of posterity it only renders the transient splendor the more vain. Such monuments have their value in so far as by keeping constantly before the people examples of true greatness they serve to educate a nation. But who does not know that the chief motive which erects statues of great men is national vanity, and when will nations learn that they can serve even this selfish aim far more effectually by promoting with pecuniary means the labors of their great scholars while living, and carefully cherishing their works when dead. Every student of science would have preferred that the memorial before us, worthy as it is of one of the noblest scientific scholars which England has produced, should have been a tribute of the nation rather than an offering of two devoted friends, and all must regret that a similar tribute has not been paid to Graham's great contemporary, Michael Faraday.

The great value of memorial volumes like the one which Graham's two friends have presented *gratuitously* to the scientific world is to be found in this,—that they add finish to the completed work of the great man, they commemorate, and exhibit its unity. The investigations of almost every successful student of nature are directed by a few controlling ideas, and although the parts may seem to his contemporaries to be disconnected, because the results are published at intervals, yet when the work is done, and is seen with the perspective which time gives, the plan appears; and no greater service can be done for the departed scholar than to bring together his scattered papers, and make evident to the world the great thoughts which give unity and dignity to the whole; and not only is the work of his life thus made to appear more worthy, but, what is more important, it is rendered more useful to science.

The trait we have pointed out is most conspicuous in the investigations of Graham, and the service we have commended has been most ably rendered to his deceased friend by Dr. Angus

Smith, in the admirable "Preface and Analytical Contents" of the volume we are noticing. It is this feature which in our estimate renders this volume a more worthy memorial than either of the works to which we have referred above. In a biographical notice prepared for the Proceedings of the American Academy of Arts and Sciences, and reprinted in this Journal, III, vol. i, p. 115, we have already expressed our appreciation of the remarkably unique character of Graham's work, and shown that it forms a large part of the experimental basis of the recent science of molecular mechanics; and we are glad to find that our estimate of these investigations has been so fully confirmed. There is but one observation which we desire to add.

Faraday and Graham were two of the most successful discoverers who in any age have illustrated the annals of physical science, and their success was wholly due to the power with which they wielded the inductive method of experimental research. Experiment guided by analogy ever has been, and ever must be, the fundamental condition of all progress in physics, and we regret to see a tendency to undervalue this mode of investigation as compared with the more rigid methods of mathematical deduction. The ability to devise crucial experiments, and to overcome the difficulties which the material conditions of every new physical problem present, is a talent of fully as high an order as that which can marshal differential equations and draw forth the truths which they involve; and this mathematical skill, all important as it is, and essential to the later developments of the science, would be powerless without the data, which experiment has supplied. We would therefore most earnestly commend to the attention of the students of physics, these experimental researches of Graham, as an example of what great results can be attained by purely and very simple experimental means. J. P. C., JR.

Newport, July 9th.

II. Geology and Mineralogy.

1. *Bulletin, Vol. iii, No.* 3, *of Hayden's Expedition.*—The publication of this Bulletin was announced in the preceding number of this Journal. The following are notes from the volume.

Professor Cope refers the Lignitic beds of the Judith River region to the Cretaceous, making the Eocene Tertiary commence with the Wahsatch group. These Judith River beds overlie the Fox Hills group, which is the Upper Cretaceous No. 5, of Hayden & Meek, a rusty sandstone separating the former (which he makes Cretaceous No. 6), from the black shales of the latter. These Judith beds have a thickness of 300 to 500 feet, and afford, above as well as below, various Dinosaurian remains. From the upper two-thirds of a section of 332 feet, Dr. Cope enumerates the following: *Lælaps*, 6 species; *Troödon*, 1; *Aublysodon*, 2; 12 others of the genera *Zapsalis*, *Paronychodon*, *Palæoscincus*, *Dysganus*, *Diclonius*, *Trachodon*, *Monoclonius;* also species of *Crocodilus;* of the Testudinate genera *Trionyx*, *Plastomenus*, *Polythorax*, *Comp-*

semys, *Emys;* of *Rhynchocephalia*, 4 species; *Batrachia Urodela*, 5; others of *Lepidosteus*, and *Ceratodus*.

Mr. Cope makes the Lignitic formation include the Judith River and Fort Union epochs, as defined by Meek, and regards the Laramie or Bitter Creek beds as representing other epochs.

Prof. White discusses the age of the Lignitic group in connection with his review of the species of fresh-water and land shells. He refers the Judith River and Laramie groups to the *Post-Cretaceous*, and recognizes the same five Cretaceous groups laid down by Hayden and Meek; but he makes the Cenozoic or Tertiary commence near the base of the Fort Union group, in the Upper Missouri region, and also near that of the Wahsatch in the Green River region; so that the Tertiary of the Green River region includes (beginning below) the Wahsatch (except its earliest part), Green River, Bridger and Brown's Park groups, all of fresh water origin; and that of the Upper Missouri River region, the Fort Union, Wind River and White River groups. The Laramie group and the lower portion of the overlying Wahsatch (some 500 or 600 feet) is the portion of the series about which the age, whether Cretaceous or Tertiary, is in dispute. The final change from brackish to fresh-water formations takes place at the close of this early part of the Wahsatch.

Dr. Peale describes mountains consisting partly of mixed eruptive and sedimentary rocks, occurring in Colorado. Among the examples of them there are the Spanish Peaks, two isolated mountains east of the Sangre de Cristo Range; two areas of low hills in Middle Park; Mount Guyot and Silverheels, northeast of South Park; four Elk Mountain areas, the Italian, White Rock, Snow Mass and Sopris; the Sierra la Sal, 120 miles west of the Elk Mountains, and others. The areas are isolated, and in regions of sedimentary rocks. The mountains consist partly of trachyte and rhyolyte, or of granite, into which the trachyte graduates, or less commonly of dioryte. The sedimentary rocks are intersected by dikes, and the beds have sometimes been carried up, broken off, overturned, and forced apart by intrusive sheets; or the liquid rock has forced its way through the strata and spread out with scarcely any displacements; or, on reaching the shales, it has pushed its way between the layers, lifting those above. The sediments adjoining are sometimes altered and even disguised, in other cases they are unaltered by the heat. The rocks penetrated and overlaid are in part the Cretaceous; and in one of the West Elk Mountain areas, Upper Cretaceous; the eruptions were certainly post-Cretaceous. In Park View Mountain and Spanish Peaks, Lignitic strata are intersected by trachytic dikes. Dr. Peale concludes that the eruptions are all of the same age; that they occurred after the elevation of the mountain ranges; and that the trachyte and other rocks have resulted from the fusion of metamorphic rocks lying beneath—the fusion being due to the heat occasioned by the movements and plication.

A Fourth edition of the "Lists of Elevations" by H. Gannett has been issued. It contains the Hypsometric map noticed on page 387 of the last volume of this Journal.

2. *The Coal Mines of the Western Coast of the United States;* by W. A. GOODYEAR, Mining Engineer. 154 pp. 12mo. San Francisco. 1877. (A. L. Bancroft & Co.)—The author of this volume has had a ten years' intimate practical acquaintance with the coal mines of California, Oregon and Washington Territory. His work gives a clear and full description of the coal fields (none of which are older than Cretaceous), and of the mines themselves as they exist to-day, together with statistics of production, information concerning the relative value for steam purposes of the various coals which come to the San Francisco market, and other cognate matters interesting not only to geologists and mining engineers, but also to all who are connected with the coal trade. The relative value of the different coal fields is considered, and the following conclusion reached: that the mines of California cannot be relied on for much more coal; that those of Coos Bay, Oregon, the only ones yet worked in that State, will not probably be worked with a profit many years longer; that "it is unquestionably to the mines of Washington Territory and of British Columbia that the Pacific coast must look hereafter, both for its chief domestic, and its nearest and most reliable foreign, supplies of a good article of coal."

3. *On the Origin of Kames or Eskers in New Hampshire;* by WARREN UPHAM, of Nashua, N. H. (Proc. Amer. Assoc., Buffalo Meeting, 1876).—Mr. Upham describes "kames" as existing along the lower part of the valleys of almost every river in the State of New Hampshire; and as being ridges several miles in length, or remnants of them, made up of sand and fine or coarse gravel, and in some places containing occasional angular bowlders. A single continuous "kame," 150 to 250 feet high, is said to extend in the Connecticut valley from Lyme, N. H., to Windsor, Vt., a distance of twenty-four miles. Mr. Upham describes the terraces as consisting of sand, clay and fine gravel, and as covering in places the kames, and therefore newer than the kames. Their origin is referred to depositions by sub-glacial streams of the material dropped by the melting glacier before its retreat.

4. *The American Palæozoic Fossils.* A Catalogue of the Genera and Species, with names of authors, dates, places of publication, Groups of Rocks in which found, and the Etymology and Signification of the words, and an Introduction devoted to the Stratigraphical Geology of the Palæozoic rocks; by S. A. MILLER. 254 pp. 8vo. Cincinnati, 1877. Published by the Author.—This title gives the contents of Mr. Miller's work. The Catalogue is the result of a large amount of labor, and will be of great service to students in Paleontology. The Introductory chapter is judiciously drawn up; and so also a preceding chapter on the construction of scientific names in Paleontology, by Prof. E. W. Claypole, of Antioch College. The Catalogue commences with the names of fossil Plants; and continues with those of Animals, beginning with the lowest. Among Vertebrates it includes only the fossil Fishes and Reptiles. A valuable addition to such a catalogue would be a table containing the titles of the works referred to.

5. *Heights of Mountains in Western Connecticut.*—The following is a list of some of the mountain elevations of Western Connecticut, as obtained by a survey made two or three years ago by Messrs. Fyler and Civil Engineer George M. Bradford, of Winsted, and the Hon. Robbins Battell and H. P. Lawrence, of Norfolk. It will be seen that Salisbury, the northwest corner township, has elevations much higher than that of Mt. Ivy in Goshen, which used to be called the highest land in Connecticut. The elevations here given are the heights above tide water:

Spaulding's Summit, Norfolk	1,336	feet.
Platt Mountain, Winchester	1,460	"
Chamberlain Mountain, Winchester	1,480	"
Ivy Mountain, Goshen	1,642	"
Riggs Mountain, Norfolk	1,565	"
Knapp Mountain, Norfolk	1,617	"
Moses Mountain, Norfolk	1,645	"
Dutton Mountain, Norfolk	1,672	"
Summer Mountain, Norfolk	1,672	"
Haystack Mountain, Norfolk	1,672	"
Gaylord Mountain, Norfolk	1,717	"
Bald Mountain, Norfolk	1,770	"
Winrow Mountain, Norfolk	1,770	"
Mt. Bradford, Canaan	1,960	"
Clipper Mountain, Canaan	1,810	"
Bald Peak, Salisbury	1.996	"
Buck Mountain, Salisbury	2,150	"
Bear Mountain, Salisbury	2,250	"
Mount Brace	2,300	"

"The last three heights are estimated." The report of the survey says: Mount Brace and Bear are 150 to 200 feet higher than the ground they stood on, [Bald Peak, Salisbury], and unquestionably in the limits of this State,—while there is some dispute as to whether the highest point of Mount Brace, which is considerably above the other two, is in this State, or just over the line in New York. The monument to mark the State line is on this mountain near the top, and it is exceedingly probable that the highest land in the State is *exactly* in the corner where New York and Massachusetts join Connecticut. Only this seems now certain, that there is land in this State that will vary little, if any, from 2,300 feet above the sea level.—*Hartford Times*, June 14, 1877. This high land is in the Taconic range and just south of Mount Washington.

6. *On some of the conditions influencing the projection of discrete solid materials from Volcanoes, and on the mode in which Pompeii was overwhelmed.*—Robert Mallett, F.R.S., has an important paper on this subject in the Journal of the Royal Geological Society of Ireland, vol. xiv, part 3, which was read before the Society a year since.

7. *The Geological Survey of Portugal.* — The recent publications of the Survey of Portugal include a memoir on the Caves of Casareda containing human remains, by J. I. N. Delgado; on the existence of Silurian rocks in the vicinity of Alemtejo, by the same; on the Quaternary of the hydrographic basins of Tejo and Sado, by C. Ribiero; on the supply of Lisbon with spring and river waters, by the same.

C. Ribeiro has also published a memoir on flint and quartz implements from the Tertiary and Quaternary of Tejo and Sado, in the Memoirs of the Lisbon Academy of Sciences.

8. *Earthquake of Jalisco, Mexico, and eruption of the Volcano Ceboruco.*—A detailed account of the Jalisco earthquake, of the 11th of February, 1877, shaking heavily the city of Guadalajara, and of Ceboruco, a volcano in the region, by a Government Commission, consisting of M. Iglesias, M. Bárcena, and J. I. Matute, is contained in the first volume of the Anales del Ministerio de Fomento de la Republica Mexicana, Tomo i, Febrero de 1877.

9. *West Rock at New Haven, Connecticut, not the termination of the Green Mountain range.*—The ridiculous statement,* that the Green Mountains terminate in West Rock, is still afloat in the School Geographies studied in and out of New England. The following correction of it appeared nearly sixty years since, in Amos Eaton's "Index to the Geology of the United States," (p. 103) a small volume published at Troy, New York, in 1820.

"It is very strange that several publications have located the southern extremity of this primitive range (the Green Mountains) in West Rock, New Haven, which is greenstone resting on red sandstone. Such random guesses given as facts are very injurious to the science."

III. BOTANY AND ZOOLOGY.

1. *Some points of Botanical Nomenclature.*—The series of laws of nomenclature, revised and expounded by Alph. DeCandolle, and adopted at a Botanical Congress in France a few years ago,† naturally left certain practical points unsettled, or apparently so. A Belgian botanist, A. Cogniaux, asks some questions, all rising out of the way in which genera, their synonyms, and some species are succinctly dealt with or referred to in the Genera Plantarum now in course of publication; and he very naturally addresses these questions to M. DeCandolle. The latter replies, laying down the law: and the correspondence is printed in the *Bulletin de la Société Royale de Botanique de Belgique*, 1876, pp. 477–485.

The difficulty upon which M. Cogniaux fell was not very formidable, but it is one which a botanical writer has to settle, and which ought, if possible, to be settled with unanimity, and upon intelligible principles. DeCandolle seizes the principle and applies it to the case. The settlement should be satisfactory to all who really accept the principle. It may well satisfy us; for the principle is one which for many years we have strenuously maintained in this Journal. The fact is, that the name of an author, or its abridgment, appended to the name of a genus, or to a specific name, is mere bibliography, stands in the place of a citation of author, work, page, etc. For some purposes the whole citation is needed: for others the first word suffices. "When Dr.

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* See this Journal, III, x, 498, xi, 151, 1876.

† Reprinted, with comments, in this Journal, July, 1868.

Hooker, in the Genera Plantarum, characterizes a new genus, *Cerasiocarpum*, and states that it is founded upon the *Æchmandra Zeylanica* of Thwaites, but does not write *Cerasiocarpum Zeylanicum*, how is a succeeding writer to refer to this record? Shall he write *Cerasiocarpum Zeylanicum*, Hook. f.?" If this were the only kind of case coming under the rule, we should say it were best to do so,—that, although Dr. Hooker has not imposed the specific name in question in fact, he has done it by such direct construction, that, in the absence of all reason to the contrary, the name might be cited in that manner. But constructions grow; and this one may form the foundation of a superstructure which would stand very much in the way. Suppose, asks M. Cogniaux, the new genus consisted of two or more species, already published under other generic names, and these were in like manner enumerated, some with certainty, some with doubt; suppose that several species are referred to a newly proposed genus by their old names, without saying whether they are severally regarded as distinct species or not; suppose, to take an actual case, a genus is said to contain only "*two or three*" known species, while four or five species of authors under other genera are said to belong to it; suppose, to take a common case, the species of a newly-formed or newly-limited genus could not be transferred bodily from their former associations to the new without re-adjustment and alteration of some names; and finally, take *Peucadanum*, into which Bentham thrusts twenty or thirty received genera, some of them numerous in species, what is to be done? DeCandolle rightly answers these questions, first, by calling attention to the fact that, from the time of Clusius and Dodoens down to Linnæus, this suffix of authors' names is merely the commencement of, or in lieu of, a citation; that it is not a matter of homage or sentiment, or justice, but a matter of fact, i. e., of historical record. The guiding principle as to this record is, that we are not to make an author say that which he has not said. The fact is that Hooker has established the genus *Cerasiocarpum*, and has not said that the species referred to it should be called *C. Zeylanicum*. Probably that is the name which the plant should bear: possibly not. When some writer describes or enumerates it under that name, this will also be matter of record. This rule, which rigid consistency requires to be followed in such a case, is obviously the only safe one in all the following cases. It is the rule which we ourselves have endeavored to follow. It is attended by a certain amount of inconvenience in certain cases, but any serious departure from it is sure to introduce confusion and falsification of the record. But it is every way desirable that the founder of a genus should complete the nomenclature of the species at the time, whenever and so far as he can, instead of leaving it to others.

DeCandolle closes with a reminder that the same considerations apply to the raising or lowering of the grade of a name; for instance, that Endlicher should not have written *Ordo Swartzieæ*, DC., when, in the Prodromus, the rank assigned is *Subordo;*

also that, when a genus is reduced to a section of some other, we should not write after it the name of an author who established it as a genus, etc. Consistency and exact correctness require that the rule *suum cuique* should be followed even in these matters. But we do not agree in the requisition that the name of the author who first used a former generic name as that of a section, should always be appended. Sometimes it is not easy to ascertain this, or to know whether or not it has been yet so employed. And when known, we may in many cases, in print as well as in writing, innocently and safely omit the authority of a sub-genus or section, as we may that of a genus or species. A. G.

2. *Athamantha Chinensis* L.—This is a puzzle, of which a probable solution by Muhlenberg has recently turned up. The following is the character, etc., in the Species Plantarum, ed. 1, p. 245.

"*Athamantha Chinensis*, seminibus membranaceo-striatis, foliis supra-decompositis lævibus multifidis.

"Habitat . . . Chinensem dixit Barthram qui semina misit ex Virginia.

"Caulis angulatus, lævis, erectus, parum flexuosus. Folia Chærophylli, lavia. Umbella minus expansa, alba. Semina singula 5-alis longitudinalibus parvis; involucrum duplex."

In the second edition of the Species Plantarum it is added: "Statura Selini Monnieri."

In reading the botanical correspondence of Zaccheus Collins, which (as is already noted in this Journal) is preserved in the library of the Academy of Natural Sciences, Philadelphia, I found the following in a letter from Muhlenberg, dated Oct. 12, 1813.

"Among the specimens from Genessee, sent by Mr. Whitlow, there is an umbellate agreeing with *Athamantha Chinensis* L., which Linnæus had from Mr. Bartram, who had visited the Lakes. Can we find out whether in Bartram's time the name of Genessee was known, and how Bartram spelled it: perhaps *Chinesee*, and whether such a word might have been misunderstood? I have never seen Bartram's journal."

The journal referred to must be John Bartram's "Observations made in his Travels from Pennsylvania to Canada." 8vo. London, 1751. The name of Genessee is certainly older than Bartram's time.

If Muhlenberg's suggestion is the right one, as is probable, the plant is probably *Conioselinum Canadense*. Yet that hardly posseses an "involucrum duplex." There is, perhaps, a specimen in the Linnæan herbarium, which would settle this point. A. G.

3. *Repertorium Annum Literaturæ Botanicæ periodicæ curarunt* G. C. W. BROHNENSIEG, Custos biblioth. Soc. Teylerianæ, et W. BURCK, Math. Mag. et Phil. Nat. Doct. Harlemi, Erven Loosjes, 8vo.—We have before us tomm. II, 1876, and tomm. III, 1877, relating to publications of the years 1873 and 1874 respectively. Vol. I, it appears was brought out by Van Bemmelen, who sickened and died soon after its appearance. The present authors taking up the work, appear to have done it very conscientiously

and well. They put on record, in a systematic way, the titles of all the communications relating to Botany which are found in the periodicals and serials of the years in question. The contents are arranged under the heads of General Morphology, Special Morphology of the several classes and orders, Physiology, Plant-descriptions, Floras, Geography of Plants, Paleontology, etc., etc. A list of the periodicals used is given, an alphabetical index of authors, and another of Families and Genera. The work appears to be under the patronage of the Teylerian Society of Harlem. It makes a valuable supplement or continuation, so far as concerns botany, of the Royal Society's Catalogue, and has also the advantage of systematic arrangement. A. G.

4. *Sir Joseph Dalton Hooker and party on a Botanical excursion to the Rocky Mountains and California.*—Sir Joseph Dalton Hooker, President of the Royal Society, and Director of the Royal Gardens, Kew, arrived at Boston in the Parthia, on the 9th ult. He is accompanied by Major General Strachey, of the Royal Engineers, and of the India Board, the explorer and surveyor of Kamoun, etc. They proceeded at once to the Rocky Mountains of Colorado and Wyoming, in company with Professor Gray of Cambridge, and Professor Leidy of Philadelphia, escorted by Dr. Hayden, to whose Survey the party are temporarily annexed, while they make a botanical reconnoissance of the Rocky Mountain region, which may probably be extended to California.

5. *The Influence of Physical Conditions in the Genesis of Species;* by JOEL A. ALLEN. 32 pp. 8vo. (From the Radical Review, vol. i, No. 1, May, 1877.)—Prof. Allen has brought together in this paper a large number of facts—partly of his own observation—on the differences among the individuals of species connected with their geographical distribution. He draws his illustrations from birds and mammals. The differences are differences in size of body, size and form of peripheral parts, kind and intensity of color, and, to some extent, in qualities still more fundamental:—differences that had led to the establishment of many distinct species which now are known to shade into one another by hardly perceptible gradations. The author after pointing out many examples, argues that the direct influence of climate or geographical conditions--and not natural selection—is the chief source of the variations, a conclusion the facts clearly establish.

6. *Sir Wyville Thomson, and the working up of the "Challenger" collections.*—The May number of the Annals and Magazine of Natural History contains an article by Professor P. M. Duncan charging Sir Wyville Thomson with partiality and lack of patriotism in the distribution of the "Challenger" collections for description. Mr. Duncan refers especially to the Echini, Sponges, and Protozoa, a portion of which have been sent for description to America and Germany, which, according to him, belong of right to British naturalists.

If Sir Wyville Thomson has neglected any one's interests in the matter, he may be said to have disregarded his own, by sending part of the Sponges to Oscar Schmidt; for surely no one has a better claim than Sir Wyville himself, to whatever distinction may be gained in working them up as a whole. Mr. Duncan speaks of the destination of the Echini as a wrong done to Dr. Thomas Wright, and that of the Radiolaria as a slight upon Mr. Carter. Without discussing the merits of any English naturalist as compared with those selected, it certainly is no slight to any investigator of the Protozoa, that the Radiolaria should have been intrusted to Haeckel. And we may suppose that in sending the Echini to be worked up at Cambridge, Sir Wyville was strongly influenced by the fact that a larger amount of material for the comparison of recent Echini is to be found at the Museum of Comparative Zoology than in any other institution; which circumstance, added to Mr. Agassiz's familiarity with the subject, gives him unusual facility for the work.

More important, however, than any personal interest is the principle involved in this distribution. The same cosmopolitan spirit has guided Sir Wyville on previous occasions. A reference to past transactions shows not only that he has been consistent with himself, but that he could scarcely have acted otherwise if the best and fullest scientific results were to be obtained from the materials in question. On the return of the Porcupine in 1869, it was agreed between Sir Wyville Thomson and Mr. Agassiz, then acting for the Coast Survey under whose auspices similar deep sea dredgings had been made, that they should send their respective materials, as far as possible, to the same persons, and secure the best coöperation by choosing specialists of known ability regardless of nationality. We may add, that a few years later, when the collections of the Hassler expedition were ready for distribution, the same policy was continued with even greater disregard of national predilections than in the case of the "Challenger," the material being divided among sixteen specialists, twelve of whom were either Swedes, Frenchmen, Englishmen, or Germans.

We cannot regret that Sir Wyville Thomson in distributing the invaluable collections of the Challenger has persisted in the same course. In so doing he has selected, as far as possible, those investigators whose familiarity with the results of his own earlier deep-sea dredgings, and with those of the United States Coast Survey, gives them an unquestionable advantage in working up these later collections. In short, it seems to us, that in this final division, Sir Wyville has manifested the discriminating judgment which has made the Challenger expedition an exceptional one throughout; exceptional, not as Mr. Duncan thinks it should have been in its exclusively national character, but exceptional in well laid and admirably executed plans, conceived in a liberality of spirit which lays the whole scientific world under obligation.

7. *American Addresses, with a Lecture on the study of Biology;* by THOMAS H. HUXLEY. 164 pp. 8vo. London, 1877. (Macmillan & Co.)—These addresses include those delivered by Professor Huxley in New York, in 1876, noticed on page 399 of volume xii of this Journal (1876), and also his address on the occasion of the

opening of the Johns Hopkins University, delivered at Baltimore on the 12th of September, 1876, and a lecture on the study of Biology, in connection with the Loan Collection of Scientific Apparatus, South Kensington Museum, delivered December 16, 1876.

IV. ASTRONOMY.

1. *Notice of the Meteor of June* 12, 1877; by Professor DANIEL KIRKWOOD. (Communicated.)—On the evening of June 12, 1877, about fifteen minutes before 9 o'clock, a large meteor was seen in Indiana, throughout almost the entire extent of the State. The *Plymouth Democrat** of Thursday, June 14th, contains the following notice of the phenomenon:

"A remarkably brilliant meteor, of a bluish color, passed through the heavens from west to east, last Tuesday evening at about fifteen minutes past 9 o'clock. The movement of the meteor was much slower than is usual with such bodies, being visible for several seconds. It left no trace of its course, as some former meteors have done. Its elevation was about thirty degrees, and the space traversed was about twenty degrees, according to the opinion of a city paper."

The time here given, fifteen minutes *past* 9 o'clock, is certainly erroneous, as the meteor was seen *before* 9 both in Muncie and Bloomington. The altitude is probably that at which the body disappeared. According to the *Muncie Times* of June 13, the meteor as seen in Delaware County was in the north, moving from west to east, nearly parallel to the horizon, at an elevation of about 40°. Mr. F. M. Parker, a graduate of Indiana University, observed it carefully at Bloomington, Monroe County. When first seen it was about 15° east of north at an altitude of 17° or 18°; its apparent magnitude was one-fourth that of the moon; its motion eastward; the length of its visible track, about 20°; and it disappeared at an elevation of 12° or 13°. With the exception of the Bloomington observations the data are very uncertain. They justify the conclusion, however, that the meteor's motion was direct, and that its height above the earth's surface at the moment of its disappearance was more than thirty miles and less than forty.

Bloomington, Indiana, July 2.

2. *Micrometric measurement of Double Stars.*—A memoir on this subject, extending to 266 pages, by N. C. Dunér, is contained in the Acta Universitatis Lundensis, tom. xii, 1875–76.

3. We are glad to learn that Mr. Burnham has been granted again the use of the large telescope in the Chicago Observatory.

4. *Handbook of Descriptive Astronomy;* by GEORGE F. CHAMBERS. 3d edition. Clarendon Press Series. Macmillan & Co. London: 1877. 8vo, 960 pp.—The first edition of this excellent work was published about ten years ago and is probably known to most amateur astronomers. In that edition there were

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* Published at Plymouth, Marshall County, near the northern boundary of the State.

several very serious deficiencies. The present edition is much enlarged, and these deficiencies have been supplied. Some of the chapters are, from the increase of our knowledge, almost entirely new. The net increase in the volume is not less than 200 pages. The work is, as its title implies, strictly *descriptive.* The author has in general avoided all theoretical discussions. The law of universal gravitation and the nebular hypothesis are alike omitted. The same is true of spherical astronomy and all methods of computation except the very simplest. The volume is therefore a handbook of the known facts of Astronomy, stated with the least possible amount of mathematics. It is not designed or fitted to be a textbook, but it is not unsuited to general reading, and the amount of information crowded into its pages makes it extremely convenient for reference by the teacher and almost indispensable to the amateur observer.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Abstract of a pamphlet entitled Reflections sur les Chronometres*, par J. A. ROUYAUX, Enseigne de Vaisseau. Translated by Lieut.-Com. C. H. DAVIS, U. S. N.*

Part I—Contains an exposé of numerous inconveniences in the direct application of formulæ to chronometers at sea, and a resumé of the advantages to be derived from an application of the formulæ to the *differences of rates* observed daily at sea.

Part II—Contains a demonstration of some properties of lines of equal rates and temperatures (lignes isothermes et lignes isomarches).

As a necessary corollary follows an examination of the results furnished, during a cruise of thirty months, by the chronometers of the *Decrès.* This examination, which in general confirms the views of Yvon Villarceau, reveals a nearly new fact: the influence which the action of the screw propellor may have on chronometer rates. A final note contains the analytical demonstrations involved in the work.

Part I.—The object of all researches on chronometer rates is a double one. 1. By a comparison of dates and temperatures, with corresponding rates, to find a law which governs these variables. 2. This law found, to apply it in such a way as to determine the rate for a given date and temperature. The common method of proceeding is, by means of careful observations, to determine rates as often as possible, the temperatures being observed at the same time. When a sufficient number of observations has been accumulated, to form a number of equations of condition, and from them determine the values of the coëfficients in the formula chosen as best applicable to the case in point. Another method is to record the rates observed, with corresponding temperatures, in the graphic form of curves.

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* This abstract of one of the latest contributions to an important subject is given with a view to make public a research which would perhaps have little currency in this country, and without committing the translator to the views therein expressed, from some of which his own investigations have led him to differ.

The inconveniences of these two methods as applied to chronometers on board ship are:

(1.) The length of time necessarily involved in the preliminary investigation: for in order to have a sufficient number of equations of condition there must be great differences in the observed temperatures, and these differences will only appear with change of seasons.

(2.) There must frequently occur, on board a cruising ship, interruptions of the regular observations.

(3.) In consequence of these interruptions the observations may be badly distributed on the scale of temperatures.

(4.) Skill is necessary in the observer.

(5.) The observations so laboriously collected and studied represent only the *Harbor rates*, whereas the practical navigator is directly concerned with the *Sea rates*, and it is well known that these two sometimes differ widely.

The navigator on considering these many and important inconveniences will be led justly to conclude that so much labor is practically useless, and will trust as implicitly to the regularity of his chronometers, as to the demonstrations of a formula based on such uncertain conditions.

It is proposed, therefore, to apply the formula, not to the rates themselves, but to their differences, or what is the same thing to the second differences of daily comparisons. These differences, when three chronometers are used, may be obtained daily, without regard to the actual value of the rates, both at sea and in port.

The length of time may be diminished, as observations are furnished every day; the interruptions in the observations will not occur; the observations will be better distributed on the scale of temperatures; talent of observation will not be necessary; two chronometers will be followed at once; and finally the perturbations of sea rates appear directly.

There is one decided inconvenience in this method, the importance of which it is impossible to deny, viz: that the result practically useful to the navigator is the variation of *the rate itself*, which must still be sought by the ordinary methods, because this method only furnishes the variation in *difference of rate.* The ordinary methods may however be facilitated by a study of the difference of rates, and are of themselves insufficient to control the regularity of sea rates or the validity of the proposed formulæ.

Since the rate of a chronometer may be regarded as a function of the two variables, time and temperature, it may be expressed by the development of a series (Taylor's theorem), and Mr. Yvon Villarceau was the first to apply this solution to the problem. His formula is the general one for all chronometers. It is shown that the formula may be applied to express the *difference of rate* of two chronometers, exposed to the same temperature, at the same times.

Part II.—Several properties of chronometer-rates are implicitly contained in the formula of Yvon Villarceau. The importance of these properties is that they are *necessary* and *sufficient* consequences of the formula, and are consequently verified or not verified at the same time as the formula, and are capable of replacing it either as proof of an admitted law, or as a control on the regularity of rates. Their practical utility consists in the fact that their graphic construction is much easier than that of the formula.

Without entering into their mathematical demonstration these properties may be briefly stated as follows:

(1.) All the rates corresponding to the same temperature are distributed on a parabola having its axis parallel to the axis of rates.

(2.) The points corresponding to the same value of rate are all situated on a conic, and all the conics obtained for different values of rate have the same center and are similar.

[It must be borne in mind that the points corresponding to equal temperatures are points on the curve of rates, and the points corresponding to equal rates are points on the curve of temperatures.—*Translator.*]

By giving to the curves of temperatures and rates the same axis of time these properties will appear in a graphic construction of the curves.

A study of the chronometers of the *Decrès* is given to show the influence of vibrations caused by the screw of a steam vessel on the rates of chronometers on board.

A practical way of correcting rates at sea, by the application of the formula to their differences, is as follows:

Suppose that the normal values of the rates a, b, c, . . . and their differences $b-a$, $c-a$, . . . have been determined, for a given time and temperature [by any adopted formula].

If time and temperature alone affected the rates these determinations might be adopted as the correct *sea rate.* Compare the differences thus deduced with the second differences in the daily comparisons actually observed for the corresponding date. To deduce variations in the rates themselves we may reason as follows:

(1.) If none of the differences $b-a$, $c-a$, . . . have varied it may be admitted that the rate itself has not varied. Because, if the rate has varied it is almost impossible that the perturbations da, db, dc, . . . should all be equal and of the same value.

(2.) If one or several of the differences have not varied it may be admitted that the rates on which they depend have not varied. For in order that a difference $b-a$ should remain constant, while b and a both change, it is necessary that $da=db$, which is improbable.

(3.) If all the differences have varied there is no longer any probable rule to govern the corrections. In this case the change is probably due to the action of the screw, and if the effect of this action is once determined, it may be the same in a second case.

E. S. H.

2. *Earthquake wave of May 9th and 10th.*—This wave, some account of which is given on page 77, reached New South Wales

(according to a report from the Pacific Steamer, Australia) on the morning of the 11th of May (Australian time). At 5^h 20^s A. M. the tide guage at Fort Denison recorded the first of the series of waves. The oscillations continued through the day and reached their maximum at 2 P. M. the height then being three feet six inches. Telegrams from New Zealand report that similar waves were felt on the east coast, from the Bay of Islands to the bluff, commencing at 5 o'clock A. M. The maximum height was six feet.

3. *Tides of the Arctic Seas.*—These tides are mathematically discussed by Prof. S. Haughton in papers published in the Proceedings of the Royal Society, the last of which (Part vii) was read on the 17th of February last.

4. *Massachusetts Institute of Technology, Boston.*—In connection with this excellent institution, laboratories for the instruction exclusively of women were open for occupancy on the 23d of October last, and have been in successful operation through the winter and spring. The design is to afford facilities for the advanced study of Chemical Analysis, Mineralogy and Chemistry as related to Vegetable and Animal Physiology and to the Industrial Arts. The laboratories are excellent in arrangement and are furnished with all needed apparatus. The laboratory is under the charge and instruction of Professor John M. Ordway and Mrs. Robert H. Richards. The terms are $200 a year for a full term of eight months, six days per week. Students are also taken for one or two days per week.

5. *Transfer of the Shepard Collections to Amherst College.*—The scientific resources of Amherst College have recently been greatly increased by the acquisition of the large collections of minerals, meteorites, fossils, plants, etc., of Prof. C. U. Shepard. These collections have been for more than twenty-five years deposited in the Amherst College Museum; and while there they have been ever increasing in extent through the zeal and liberal outlay of Professor Shepard, until finally they had reached a value, according to his estimate, of full seventy thousand dollars, excluding the collections in zoology, botany and archæology. From good will to the Institution, with which Professor Shepard has long been connected, the whole are now transferred to the college for little more than half this sum. The collection of meteorites ranks fourth in the world, and no institution in this country possesses a superior collection of minerals.

6. *Imperial Academy of Sciences of St. Petersburg.*—This Academy has published Part I. of a detailed index volume to its publications, covering 490 8vo pages and including the articles in foreign languages.

7. *National Academy of Sciences.*—The Academy has recently published vol. I, of Biographical Memoirs, 344 pp. 8vo, containing memoirs of J. S. Hubbard, J. G. Totten, B. Silliman, E. Hitchcock, J. M. Gilliss, A. D. Bache, J. H. Alexander, W. Chauvenet, J. F. Frazer, J. H. Coffin, J. Torrey, W. S. Sullivant, J. Saxton, H. J. Clark and J. Winlock. Also volume I, of Proceedings of the Academy. 120 pp. 8vo.

8. *Bulletin of the Bussey Institution*, Vol. ii, Part 2. 80 pp. 8vo. Boston, 1877.—This number contains the following papers by F. H. Storer: (1) on the composition of certain Pumpkins and Squashes; (2) record of results obtained on analyzing seeds of Broom Corn; (3) record of analyses of several weeds that are occasionally used as food; Chemical composition of Blue Joint grass (*Calamagrostis Canadensis*) as contrasted with that of Reed Canary grass (*Phalaris arundinacea*); (4) remarks on American Fodder rations with hints for the improvement of some of them; (5) results obtained on growing Buck-wheat in equal weights of Pit-sand and of Coal-ashes; and the following by W. G. Farlow: Notes on some Common diseases caused by Fungi.

9. *Dynamics, or Theoretical Mechanics;* by J. T. BOTTOMLEY, M.A., F.R.S.E., F.C.S. 142 pp., small 8vo. New York, 1877. (G. P. Putnam & Sons.—This little work forms one of the volumes in "Putnam's Elementary Series." The fundamental principles of mechanics are presented with clearness and precision, without the introduction of difficult mathematics, and it is thus an excellent book for the class of students for whom it was prepared.

Eighth Annual Report of the State Board of Health of Massachusetts, January, 1877. 498 pp. 8vo, with several maps. A Report of high scientific value. The chief topics are: Pollution of streams; sewerage; sanitary condition of Lynn; registration of deaths and diseases; growth of children; disease of the mind (by Dr. C. F. Folsom); health of towns.

Science Lectures at South Kensington. The Steam Engine, by F. J. Bramwell. 62 pp. 12mo, with illustrations. London and New York, 1877. (Macmillan & Co.)

OBITUARY.

SANBORN TENNEY.—Sanborn Tenney, Professor of Geology and Natural History in Williams College, Williamstown, Mass., died suddenly, on the eleventh of July, at Buchanan, Michigan, while on his way to Chicago, the point of rendezvous of a Williams College exploring party to the Rocky Mountains, of which he was the projector and leader. Professor Tenney was the author of valuable text-books on zoology and geology.

DR. STEPHEN REED.—Dr. Reed died on the twelfth of July at Pittsfield, Mass., aged seventy-six years. His name has been long connected with geological discovery in Western New England, and mainly through his account of a long train of bowlders across part of central Berkshire, which attracted Lyell and other geologists to the spot and has obtained a prominent announcement in all writings on North American drift.

C. F. WINSLOW, M.D.—Dr. Winslow, formerly of Boston, died recently in Utah, aged sixty-six years. He is the author of a work entitled "Cosmography, or Philosophical views of the Universe," published at Boston in 1853, also later of one on "Nature and Force;" and, besides, of short papers on some Earthquakes, in this Journal, and on the discoveries of human remains in California, and some other subjects.

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[THIRD SERIES.]

ART. XXII.—*On a new Process for the Electrical Deposition of Metals, and for constructing Metal-covered Glass Specula;* by Professor ARTHUR W. WRIGHT, Yale College.

IN a paper by the writer, published in this Journal, January, 1877, an account was given of a method of producing metallic films upon the inner surface of exhausted glass tubes, by the action of a succession of energetic electrical discharges. The thickness of these films could be varied, from a tenuity such that the coating barely gave indications of a metallic luster, and scarcely dimmed the intensity of transmitted light, to the point where perfect opacity was attained, by simply continuing the action of the current for a shorter or longer time. They were produced by forming the negative electrode of the metal to be deposited, exhausting the tube, and passing through it the current from an induction coil. The metallic coatings thus obtained, as seen from the exterior, were very brilliant, but the condition of the inner surface was not readily observed, and the nature of the process made it seem probable that they possessed a dull or even a frosted surface. With a view to obtain the films in a form better suited for examination, a modification of the apparatus was contrived, by which they could be deposited upon pieces of plane glass. At first this object was attained by inserting narrow slips of glass into the tube by the side of the electrode, in the manner suggested in my former paper, and very good results were gained. But, as the nearer portion of the plate received a larger share of the metal, the thickness of the deposit was not uniform, and it was found necessary to construct a special apparatus, in which the relative positions of the plate and the electrode could be varied, so as to give the latter an equal action upon all parts of the surface to be covered. The plan employed was as described in the following paragraphs.

A rather thick-walled glass globe about seven centimeters in diameter, blown upon the end of a tube twenty-five centimeters long and fifteen millimeters in diameter, was used to form the receiver. The top of the globe opposite the tube was cut off, so as to form an opening forty millimeters in diameter, and the edge ground flat, in a plane perpendicular to the axis of the tube. The end of the latter was drawn somewhat smaller in a gas-flame, and a glass stop-cock attached to it with cement. A little way above this, a platinum wire was fused into the glass to serve as the positive electrode. The cover of the vessel was made by cutting from a similar globe a portion corresponding in size to the part removed, but with the neck attached, the two pieces being carefully ground so as to fit closely. When they were placed together, a little cement applied to the outside along the line of juncture rendered the joint perfectly air-tight. The tube or neck of the cover was five centimeters long, and was also somewhat reduced at the extremity by drawing it smaller. Into this was cemented a small and thick-walled tube extending to a point near the center of the globe. A platinum wire was placed in this tube, and was fused in at the top, enough being left projecting to form a small loop for the attachment of the wire from the coil. The inner end of the wire terminated at about one centimeter from the lower end of the glass tube. Into the latter was slipped a wire of the metal to be deposited, which, in all cases, was the negative electrode,—the part within the tube being long enough to make good contact with the platinum wire, and being bent somewhat so as to cause it to retain its place by friction. In some of the experiments a different cover was used, made from a glass funnel, the neck of which was left somewhat longer to afford more room for the swinging electrode, as described below, and the tube carrying the latter was fitted into the top by grinding so as to make an air-tight joint.

For the support of the plate, a small watch-glass, about three centimeters in diameter, was employed, to one edge of which a thread of glass was fused by a blow-pipe flame, and then bent so as to form a loop by which it could be suspended like the pan of a balance. A small hook of glass was also attached to the side of the thick tube carrying the electrode, and upon this the pan was hung, the loop being so formed as to allow it to swing freely in all directions. The pan, when in place, was about fifteen millimeters below the end of the tube from which the electrode projected, the latter being adjusted to the proper distance by sliding it up or down in its support as occasion required. By slightly inclining the globe the extremity of the wire could thus be readily brought over any point of the plate. In some of the experiments the plate was stationary, being held in a little tripod of glass threads, or simply laid upon the bottom of the globe. In these cases the tube holding the electrode was jointed near the top, the two portions being connected by a hook and loop of platinum or magnesium wire. It could thus be made to traverse all parts of the plate by giving suitable movements to the globe.

When adjusted and closed the receiver was attached to the Sprengel pump. By means of a small air-pump of the ordinary construction, connected with this by a stop-cock and flexible tube, the whole apparatus was exhausted as far as possible and then dry hydrogen admitted, this being repeated two or three times in order to remove the air and moisture. The process of exhaustion was then completed with the mercury pump. The degree of rarefaction required varied somewhat with the metal to be deposited, but was rarely above 2·5 millimeters. For platinum the best results were obtained, when it was from 1·5 to 1·75 millimeters. The use of hydrogen is not in all cases necessary, as some of the metals can be deposited perfectly well with only air in the receiver. This is especially the case with gold, but platinum, although ordinarily not easily combined with oxygen, becomes tarnished with a film of what apparently is the blue oxide, unless the air is removed. The electrode itself was formed of a small wire, usually not more than one-fourth of a millimeter in thickness, bent at the end into a circle three or four millimeters in diameter, the plane of which was perpendicular to the straight portion of the wire entering the glass tube, and parallel with the surface of the glass plate situated beneath it. Its distance from the latter was generally about three millimeters, though considerable variations were possible. When it is farther away the process of deposition goes on much more slowly, though the results are in most cases quite as good as when it is nearer. After the process of exhaustion was completed, the stopcock was closed, and the apparatus removed from the pump, for greater convenience of manipulation in applying the current.

The electrical apparatus employed consisted of an induction-coil capable of giving sparks four or five centimeters in length, and a battery, the power of which could be varied according to circumstances. It consisted usually of pint Grove cells, from three to six in number, not completely filled, or charged with rather weak acid, and a plunge-battery of five cells, of which one, two, or more were used, as occasion required, the whole being joined in a continuous circuit. By immersing the plates of the plunge battery more or less, as well as by varying the number in the circuit, the strength of the current could readily be changed within the limits desired. The various metals required currents of different strength, and the power best suited to each had to be determined by trial. It was found advisable in most cases to regulate it so that the temperature of the electrode was below that of a red heat, or such as barely to redden it. Of course with the more fusible metals it was necessarily much lower than this. The metal is actually volatilized by the discharge, as is shown by the fact that the characteristic lines of its spectrum may be seen with a spectroscope, and the film is formed by the condensation of its vapor upon the cooler glass surface. For the production of films with brilliant surfaces, the strength of the current must not be great enough to give the discharge a disruptive character, as this separates some of the metal in the form of powder.

The primary object of the experiments was to obtain films of the different metals upon thin pieces of flat glass for the purpose of investigating some of their optical characters. The apparatus proved to be perfectly successful in its operation, and beautiful films of gold, silver, platinum, and bismuth, were obtained with ease and certainty. As has been mentioned, it seemed probable that the surface of deposit would be dull, but the first trial showed that this anticipation was incorrect, and the films when removed from the receiver exhibited surfaces of exquisite perfection and the most brilliant polish. They can only be compared to the surface of clean liquid mercury, far surpassing in luster anything that can be obtained by the ordinary methods of polishing.

This circumstance suggested at once a valuable application of the process in the production of specula for optical purposes, and the subsequent investigations were directed to this end. The mirrors first made had been formed upon disks of thin glass, such as are commonly used as covers for microscopical objects, those being selected which were most free from defects, and had the best surfaces. By means of a very delicate assay balance, the weight of the glass disks, both before and after receiving the deposit, could be obtained to the one hundredth part of a milligram, and hence it was easy to calculate the thickness of the metallic layer in any instance. By this means the relative transparency of the different metals can be determined, and the relation between the amount of light transmitted and the thickness of metal traversed by it. The more particular consideration of these and some other matters of interest as bearing upon the optical characteristics of the metals is deferred to another time, and it is only necessary to mention here the results of some measurements which were made in order to determine the limiting thickness of a film in regard to the transmission of light, that is, the thickness of a film which would allow only an inconsiderable proportion of the incident rays to pass through. As the metallic luster is developed gradually with the increasing amount of metal, showing conclusively that light actually penetrates these substances to a certain depth, it was important to ascertain whether the thickness of the layer, sufficient for a virtually complete reflection of light, would be great enough to affect perceptibly the figure of a mirror of glass upon which it was laid down.

Experiments for this purpose were made with gold and platinum, and the process of deposition was continued until the films appeared to have just reached the condition of complete opacity. On removing them from the receiver, however, it was found in both cases that a very small amount of light was still transmitted, as, on holding them close to the eye, a brilliant object, like the sun or a bright flame, could be seen through them. The thickness of the gold layer was found to be 0·000183 mm., that of the platinum 0·000174 mm., or approximately one-fourth the length of a wave of light at the red end of the spectrum. The gold, although thicker than the platinum, transmits perceptibly more light, showing that it is the more transparent of the two metals. As the films employed for mirrors may be much thinner than the amount mentioned without an appreciable diminution of the intensity of reflected light, it is evident that the figure of a perfectly wrought glass mirror will not be changed, when the metal is uniformly deposited, to such an extent as to affect its performance unfavorably. A platinum film of one-fifth the thickness of the one described forms a brilliant mirror, transmitting but a very small percentage of light. The perfect control of the process obtained by the use of the movable electrode will even make it possible to apply the method of local correction for the improvement of a defective figure, or to parabolize a spherical mirror by depositing the metal in a layer increasing in thickness toward the center, though, of course, it would be better to avoid a somewhat tedious operation by securing the perfect form of the glass beforehand.

Of the metals that are suitable for the formation of specula, platinum appears to be the most valuable. For while, when well polished, it is but little inferior to silver in reflecting power and freedom from color, it does not become tarnished by oxidation or the action of sulphurous gases, and when dulled by atmospheric deposits the surface can be cleaned by washing with water or with acids, which is an important advantage. By the method here described it can be deposited upon glass surfaces very easily, and a mirror of the most perfect surface produced at once, without the necessity of a single touch to complete it. Several such mirrors have been made in the course of these experiments, by the use of concave glass lenses, with the most satisfactory results. The metal film adheres strongly to the glass, and when of sufficient thickness appears to be very firm and hard. In mirrors silvered by the ordinary method, trouble is often experienced from the insinuation of moisture between the glass and the metal, resulting finally in the separation of the latter. In those prepared by the new process the adherence of the film is so close as to render such an effect impossible. As a test of this, a small silvered speculum was placed in a beaker of water where it remained for two weeks, and besides this was wetted and dried repeatedly, without showing the slightest tendency to suffer the penetration of the moisture. Similar results were also obtained with platinum and gold films.

With silver the process likewise succeeds well, but it is more difficult to obtain good surfaces than with gold or platinum. The metal is volatilized with extreme ease by the action of the current, and the energy of the discharges must not be too great. Of several trials made with this metal the most successful was one in which not only the degree of exhaustion of the receiver was less than had been employed in other cases, being only to three millimeters, but the electrode was more distant from the plate, and the battery weaker. The action proceeded slowly in this instance, but with the result of producing an excellent film. With a stronger current the deposit is rapidly made, and has a fine luster, but the surface has a yellowish color. This is perhaps partially due to a slight degree of oxidation, but also appears to be owing in part to the deposition of a portion of the metal in the form of fine powder, the vapor of the silver as it streams from the electrode toward the more distant portions of the plate becoming partially condensed, and falling on it in minute particles. That such a result would follow from this cause was shown by some of the experiments in which a rather strong battery was employed. The whole interior surface of the globe was in a short time covered with the powdered metal, appearing an intense purple where thinnest, and shading gradually to deep blue where thickest, the color being the same by both transmitted and reflected light. The metallic luster was wanting, though it was readily developed when a portion of the powdery coating, which was easily removed, was rubbed against the surface of the glass with some pressure. The defect was, to a considerable extent, remedied by surrounding the electrode with a small glass tube projecting some three millimeters beyond it, so as to clear the surface of the plate by an interval of only one or two millimeters. This had the effect to cut off the lateral portion of the discharge, and to confine its action to a limited area immediately below the extremity of the wire.

The yellow tarnish is removed with the greatest ease by gently rubbing the surface with soft chamois leather and a little rouge, and the metal is so hard, that, when this operation is performed with care, the polish is not at all, or but very slightly, affected. Even then, however, the metal is not perfectly white, having still a very faint yellow tinge. It is well known that silver is not a perfectly white metal, for light which has undergone repeated reflections from polished surfaces of this metal appears yellow or reddish-yellow, though this color is not perceptible when the light has undergone but a single reflection. But the real cause of the yellowish tint may possibly be found in the very tenuity of the films, which when prepared in this way have a beautiful and intense blue color by transmitted light. When not too thick, the amount of blue rays which they suffer to pass, may be sufficient to cause, by their abstraction, a perceptible tinge of yellow, the complimentary color, in the reflected rays. If this were really the case, the coloration should grow weaker with an increase of thickness, and disappear when opacity is reached. Some of the results obtained seem to favor this view, and the probability of its correctness is strengthened by the facts related in the next paragraph, but further experiments are needed to decide the question satisfactorily.

One result of the investigation has been to show that the color of the light which has passed through a layer of metal varies somewhat with the thickness of the film. This was known to be the case with gold, and experiment has shown it to be true of platinum and bismuth also. Thus the latter in a very thin film appears a clear bluish-gray, while a much thicker film appears brownish. Platinum in a thin layer has a grayish tint, which varies, as the film is made thicker, to a peculiar brownish shade, somewhat like that of sepia, passing into brownish yellow, and finally becoming a deep yellow, even inclining somewhat to orange, in the thickest films obtained. Now this color is almost exactly complimentary to that transmitted by silver, and the possibility suggested itself of making a mirror which should be perfectly white by reflected light, by depositing first a thin stratum of silver and over this another of platinum, the relative thickness of the two being properly regulated by observing the color of the transmitted light. An experiment made with a circular disk of flat glass was perfectly successful, the platinum being readily deposited upon the silver, the yellowish tint of which it entirely removed, producing a white and brilliant reflecting surface. By transmitted light the film, as it was anticipated would be the case, has a pure neutral tint, with no perceptible color of any kind.

The value of such a combination for specula is evident, for though until careful measurements are made, it cannot be asserted that the absolute reflecting power is increased, the whiteness of the layer, and the protection afforded by having the surface covered with an unalterable metal, are very substantial advantages. In constructing large mirrors it will probably also be found to result in a material saving of time, the silver being so much more rapidly and easily deposited than the platinum. The process can also be used with great advantage for the construction of solar eye-pieces for telescopes, since the compound film can be deposited directly upon the surface of the lens, and made thick enough to reduce the intensity of the light as much as may be desired. An image, nearly or quite colorless could thus be obtained, and the disturbance of the rays should be less than that produced by the interposition of a dark glass of the ordinary kind.

As has been mentioned, some experiments were made with bismuth, and a mirror of excellent surface was obtained, but the metal is inferior to platinum in brilliancy, and has a decided color. The great facility with which films are obtained with it might recommend its use for mirrors in some cases, but for most purposes other metals are to be preferred. Attempts to produce mirrors of iron and nickel were but partially successful, as it was difficult to prevent tarnishing by oxidation. Some good iron films were obtained, however, which were very brilliant. They were exceedingly hard, and adhered to the glass with such tenacity that at first it seemed as if they had been fused into it. But when the film was dissolved off by an acid the glass was found not to have been acted upon at all. A singular characteristic of the iron in this condition is its chemical inertness. Films prepared more than six months ago and freely exposed to the air, which for a part of the time too, was excessively charged with moisture, have not shown the least alteration. Nitric acid placed upon one of them for a short time produced scarcely any effect, and nitro-hydrochloric acid acted upon it with about the same readiness as it does upon platinum. This may be due to the extreme thinness of the film, in consequence of which, even the exterior atoms of the iron, being within the range of the molecular action of the glass, are held by a force tending to oppose and neutralize the attraction of reagents that ordinarily attack the metal energetically.

It is not at all necessary that the object upon which the metal is deposited should be of non-conducting material. This is shown by the fact that the process continues to go on after the glass has become covered with a perfectly continuous layer of metal of considerable thickness. The success of the experiment of covering a silvered glass with platinum is additional evidence of the same fact. In order more fully to test the question whether a deposit could be made upon a solid piece of metal, a small silver coin was placed in the pan under an electrode of gold. It was covered in a few minutes with a beautiful coating of the latter metal, which was found to be very hard and to adhere perfectly, having also, in every respect, its proper color and luster. At the beginning of the process, while still thin enough to allow light reflected from the silver to pass, it had a greenish color, producing a curious effect.

As an example of the applicability of the process to practical purposes, it may be of interest to mention the results of some experiments in the construction of a small Gregorian telescope, the specula of which were covered with platinum by the method described, and with entire success. The larger mirror has a diameter of a little less than four centimeters, and both this and the smaller one, so far as the nature of the surface is concerned, appear absolutely faultless. As only common lenses were employed in its construction the performance of the instrument is not remarkable, but it is sufficiently good to warrant the assurance that the method will be serviceable for the production of specula of exquisite quality for optical purposes. The size of the apparatus, which, for convenience in experimenting, was necessarily small, did not permit the introduction of larger mirrors than this, but there seems to be no reason for doubting that much larger specula can be successfully made in this way. The amount of time required for obtaining the platinum covering of this mirror was about three hours, during which the coil was kept in continuous action, with a battery power equivalent to four or five small Grove cells. Mirrors of larger size would of course require a longer time, but with suitable apparatus a much stronger battery and larger coil could be used, which would materially accelerate the operation. A plate two centimeters in diameter can be covered with platinum in twenty or thirty minutes sufficiently thick to form a good speculum. For gold or silver the time would not be more than from ten to fifteen minutes.

Many useful applications of this process may be found, and its use is not limited to those metals which have been mentioned here. Moreover for many of them no other available process is known by which they can be deposited in a uniform layer and with a brilliant reflecting surface upon glass. A very thin layer of platinum, or still better of silver and platinum together, could be used with great advantage in the *camera lucida* and similar instruments. Very perfect mirrors for galvanometer needles, and for delicate torsion apparatus, can be expeditiously formed in this way, and by the use of very thin glass, or the most delicate films of mica, they may be made of almost inappreciable weight. For the mirrors of heliostats, and other reflecting instruments in which a metallic surface is necessary, the specula produced by this method will be especially valuable. For telescopes, the beautiful process of Liebig and Foucault, for forming silvered glass specula, is recommended by the ease with which it is applied, and the rapidity of its operation. But the perishable nature of the delicate silver film, and the difficulty of securing a firm and permanent adherence, are serious disadvantages. These are entirely avoided by the use of an unalterable metal like platinum; and though for instruments of the largest size the process here described may be found impracticable, for those of more moderate dimensions there is every reason for believing it may be employed with complete success. The labor and time required for its application are indeed drawbacks; but there is compensation for this in the important circumstance that the mirror comes out of the receiver with a surface of inimitable perfection, which would in fact only be injured by any of the ordinary methods of polishing.

Yale College, August 8, 1877.

ART. XXIII.—*A new and ready method for the Estimation of Nickel in Pyrrhotites and Mattes;* by MARGARET S. CHENEY, and ELLEN SWALLOW RICHARDS.

WE had occasion several months since, to make a number of determinations of nickel in mattes where, for commercial reasons, the element of time was of considerable importance. Our attention was thus called to the various processes which have been recommended for the separation of nickel from iron, and we have submitted these processes to comparative tests, but no one of them seemed perfectly satisfactory for our purpose.

The method most commonly used, perhaps, depends upon the separation of iron as a basic acetate. (Fresenius, page 363.) This method requires considerable analytical skill and practice in its use. The large dilution and subsequent evaporation necessary render the operation a tedious one, even without the repeated re-precipitations which are indispensable to a complete separation.

The method based upon the behavior of neutralized solutions at the boiling point (Fresenius, page 362), which we personally prefer to use, is open to the same objections. The process of separating the iron by ammonium hydrate, even with all the precautions recommended by various authors, has given very unsatisfactory results in our hands. By far the best success was obtained in the use of the method given by Frederick Field, in the Chemical News, vol. i, page 5 (1859). The method is as follows:

"In the case of nickel and iron, the nitrates are evaporated nearly to dryness, and, after the addition of water, oxide of lead (litharge) is added, and the whole boiled for ten minutes or a quarter of an hour. The iron is entirely precipitated, the nitrates of nickel and lead remaining in solution. After filtration, which can be effected with great readiness, dilute sulphuric acid is added, and on standing for sixteen hours the sulphate of lead is filtered off, and the nickel precipitated and estimated in the usual manner."

This process uniformly gave good results as to the separation of iron and nickel, all the nickel being left in solution. The presence of lead in the solution was somewhat undesirable, the results being too high if the nickel was weighed as oxide, and much more caution was required in the battery precipitation. All these methods require two or three days, and the quantity of the ore or matte to be operated upon is limited, usually two to four grams.

Among the numerous tests made for a more ready way were those depending upon the solubility of the sulphates in alcohol and upon the behavior of the oxalates, but no satisfactory results were reached. Finally a systematic series of tests was made with the phosphates, in the course of which it was found that phosphate of nickel is completely soluble, while phosphate of iron is almost insoluble in acetic acid, in the presence of an excess of phosphate of soda. Upon this fact, which we had not found mentioned in any work that we had consulted, we based the following process.

The ore or matte is dissolved in hydrochloric acid with the addition of a little nitric acid. All the metals of the arsenic and copper groups, if present, are separated by means of hydrogen sulphide with the usual precautions. The filtrate is boiled to drive off the excess of hydrogen sulphide, the iron is oxidized by nitric acid, and ammonium hydrate is added until a permanent precipitate begins to form, but not until complete precipitation is effected. Acetic acid is then added until the precipitated ferric hydrate is redissolved and the liquid is of a deep red color, though not transparent. To this boiling hot solution ordinary phosphate of soda is added in excess, and the nearly white precipitate is filtered and washed with hot water containing acetic acid. The filtrate is heated nearly to boiling and caustic potash added until the odor of ammonia is distinctly perceptible. The apple-green precipitate of phosphate of nickel is partially washed, dissolved in a little *dilute* sulphuric acid, the solution rendered strongly alkaline by ammonium hydrate and the nickel precipitated by the battery.

If the ore contains more than three per cent of nickel, it is necessary to dissolve the precipitate of phosphate of iron in hydrochloric acid, dilute this solution somewhat, render it nearly neutral by ammonium hydrate, add twenty-five or thirty cubic centimeters of acetic acid, and re-precipitate by phosphate of soda. The filtrate is added to the first filtrate. If the solution has been rendered alkaline before the addition of acetic acid, or if an insufficient quantity of phosphate of soda has been used a small amount of iron will remain in the solution, not enough, however, to interfere with the battery precipitation of the nickel. The solution of phosphate of soda should be a saturated one, and, if it is heated separately, the troublesome boiling of the bulky precipitate is avoided. By the aid of the filter pump this precipitate is readily filtered in spite of its unpromising appearance.

The advantages of this method are: 1st, the concentration of the solution. It may contain ten to fifteen grams of ferric oxide in a half liter, instead of one gram as in the basic acetate method, and thus larger quantities of a poor ore may be operated on. 2d, A great saving of time. The nickel may be weighed in eight or ten hours from the time the ore is pulverized and ready for solution. This saving of time is mainly due to two causes. First, less care is required in case of precipitating as phosphate than as basic acetate. Second, in precipitating phosphate of nickel by caustic potash it is not necessary to concentrate the solution nor to expel all the ammonia as is the case in precipitating as hydrated oxide. An unexpected advantage is the more ready battery precipitation of the nickel from the solution of the phosphate.

Two of the so-called quart carbon cells, each half filled with the solutions (bichromate of potassium and sulphuric acid) were found quite sufficient to precipitate the nickel completely in two hours. If a strong current was used, the nickel was precipitated in a black, spongy form.

A solution containing ·375 grams Ni as chloride, and 1·183 grams Fe as chloride was made up to 250 c. c.

	Found.	Theory.	per cent.
100 c. c. of which	·1486	·150	99·06
100 c. c. "	·149	·150	99·33
50 c. c. "	·0748	·075	99·73

To the first portion, the phosphate of soda was added first, and the acetic acid afterward.

		per cent.	
Matte No. 1 gave	(phosphate method)	6·77	Cheney.
	" "	6·86	Richards.
	" "	6·48	
Matte No. 2 "	(neutralized solution)	2·08	Richards.
	" "	2·37	
		2·15	Cheney
Matte No. 3 "	(phosphate method)	7·22[*]	Richards.
	" "	7·41[†]	Hardman.
	(basic acetate)	7·79	Hardman.
Pyrrhotite No. 1	(basic acetate)	·32	Hardman.
	" "	·29	
" "	(phosphate method)	·33	Cheney.
		·25	
Pyrrhotite No. 2	(phosphate method)	·725	Richards.
		·686	

Massachusetts Institute Technology, Woman's Laboratory, June, 1877.

ART. XXIV.—*Notes on the internal and external structure of Paleozoic Crinoids*; by CHARLES WACHSMUTH.

(Continued from page 127.)

5. *The construction of the summit and its value in classification.*

THE construction of the ventral disc or actinal side of the calyx has heretofore received less attention than almost any other part of the Crinoids, and thereby an important aid to classification has been overlooked. I think it affords a clear and most important distinction between recent and ancient Crinoids, and shows that they fall naturally into two great divisions or groups. This view, although it does not agree with the opinion of other authors, who, in their classifications, have placed a number of Paleozoic genera in the same group with the recent Crinoids, is, as I hope to show, well founded.

Dr. F. Roemer, in the Lethæa Geognostica, 1855, p. 227, divides "*the true Crinoids*, which are supported by an articulated or jointed column" into two divisions:

a, Crinoids in which *the ventral side consists of a soft skin.*

b, Those in which *the ventral side is covered by solid immovable plates.*

Rœmer includes with the former group, *Pentacrinidæ*, *Apiocrinidæ*, *Eugeniacrinidæ*, *Encrinidæ*, *Cupressocrinidæ* and *Cyathocrinidæ*. This division seems to have been based on mere conjecture, since a membranous ventral surface has been observed only in the Pentacrinidæ and the recent Crinoids generally, though it is probable that *Eugeniacrinus* and several allied genera had that summit structure. In the Apiocrinidæ and Encrinidæ however, the general construction of the dorsal or abactinal parts, the massive plates, both of calyx and arms, indicate rather a closer relationship with the ancient Crinoids and suggest the existence of a solid dome. The latter becomes more probable since a solid vault has been discovered in *Belemnocrinus.* This genus is in its generic formula and general form almost identical with the recent *Rhizocrinus,* which on the contrary is covered by a soft peristome. Both are closely related to *Apiocrinus; Belemnocrinus* particularly has the same heavy body plates and the small visceral cavity, and it appears to me that *Apiocrinus* is more nearly allied to the Paleozoic type than to the recent *Rhizocrinus.*

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[*] Mrs. Richards lost a portion of the washings by the breaking of a beaker.

[†] This was Mr. Hardman's first trial of the phosphate method and not enough phosphate of soda was added to produce a *white* precipitate.

The *Cupressocrinidæ* and *Cyathocrinidæ* are the only groups from Paleozoic formations which Rœmer places in his division *a.* Dr. Schultze, who adopted Rœmer's classification, included in the *Cupressocrinidæ* the genera "*Synbathocrinus* Phill. and *Phimocrinus* L. Schl.," in which he is undoubtedly correct, for stronger reasons even than he himself perceived. These two genera agree with *Cupressocrinus* not only in the simplicity of their arms, but also in the so-called "consolidating apparatus," which he describes and figures in the latter. The apparatus is placed horizontally in *Cupressocrinus,* upright and turbinate in the two other genera. When the consolidating plates in *Synbathocrinus* are preserved, the ventral side appears to have two separate apertures, a lateral proboscis and a central mouth. And so the genus was originally described. This is, however, a misconception. By removing carefully all the arm joints from a specimen of *Synbathocrinus,* I discovered the central aperture perfectly covered with a number of small plates, and to this summit, as it might be called, were attached narrow lateral extensions, composed of alternating pieces, which passing downward, covered the little grooves that lead to the arm furrows. The consolidating apparatus here forms in fact a part of the solid vault. It is reasonable to conclude, that in the allied genera *Cupressocrinus* and *Phimocrinus,* so closely related to *Synbathocrinus* otherwise, the central opening was closed, and that the consolidating plates were further overlaid with plates forming the floor of a passage in connection with the arm furrows and visceral cavity. The small plates which extend out to the arms are in the specimen but partly preserved and the connection with the arm-furrow is interrupted, but there can be no doubt that the channel underneath contained the food groove and ambulacral canal which I have described in *Cyathocrinus.* The covering of the central opening of *Synbathocrinus* resembles in a remarkable degree that of the central aperture of the *Blas-*

toids, and it seems to me highly probable that the consolidating plates are homologous with the partly hidden deltoid pieces of the latter.

Among the Cyathocrinidæ, Rœmer included genera of widely different types. Besides the typical one, he enumerates nine genera, only two of which, *Heterocrinus* and *Graphiocrinus*, have the characteristics of the *Cyathocrinidæ*, and both of them evidently possess a solid dome, as is proved by their heavy proposcis. All the remaining genera belong to other groups. *Macrostylocrinus* resembles *Ctenocrinus* Bronn, and *Cytocrinus* Rœmer so closely, that they may yet prove to be identical. Rœmer, however, places *Ctenocrinus* with *Glyptocrinus* among the Crinoids with a solid dome, and *Macrostylocrinus* among the *Cyathocrinidæ*. *Macrostylocrinus* is allied to *Melocrinus*, and has undoubtedly a similar summit structure. The same may be said of *Schizocrinus* and *Dimerocrinus* which are not at all related to *Cyathocrinus*.

The genus *Cyathocrinus* was originally described by Professor Phillips and Mr. Austin as having a separate mouth and vent, which was considered by these authors and others to be its chief distinction from *Poteriocrinus*. Accordingly, all species with a proboscis or solid dome, though otherwise agreeing with *Cyathocrinus*, were referred to *Poteriocrinus* or some allied genus. Meek and Worthen, however, proved in the Geological Report of Illinois, vol. v, p. 325, that in perfect specimens, the central opening is closed. The covering of *Cyathocrinus* is exceedingly interesting, and throws light upon the summit structure of many genera. I shall herein refer frequently to Meek & Worthen's excellent figures, vol. v, Plate IX, figs. 13 and 14.

Looking only at fig. 14, one would at first naturally suppose there must have been, during the life of the animal, two distinct openings in the vault. But on examining it more critically and comparing it with fig. 13, it will be found that fig. 14 represents simply the consolidating apparatus as figured by Rœmer and Schultze in *Cupressocrinus*, placed here exactly as in that genus, and consisting of five large pieces, alternating with the upper edges of the first radial plates. The plate of the anal side is larger than the others and forms the base of the inner side of the proboscis. The five pieces which connect with each other laterally, extend inward for some distance, but not so far as to meet in the center where there is a semi-circular or heart-shaped opening. Along the sutures, between the five plates, a comparatively large furrow from each arm base extends inward and leads to the central opening. Examining now fig. 13 we find the general aspect of the ventral disc entirely changed. The lateral opening has been transformed into the base of a proboscis, and the consolidating plates are partly covered, leaving but a small uncovered space in the form of a delta in the interradial areas. The central opening is vaulted over by a number of various sized pieces, the largest one occupying the side toward the proboscis. The shallow groove between the sutures of the consolidating plates is arched by a double series of alternating plates, forming underneath a passage for the ambulacral canal and food groove. The vault, thus closely resembling that of *Synbathocrinus*, was in all probability arranged on a similar principle in *Cupressocrinus*. The same plan, with slight modifications, prevailed in *Poteriocrinus*, *Scaphiocrinus* and all genera with an *inflated or balloon-shaped ventral sac*. Among the latter, the center of radiation is frequently found to be pushed toward the anterior side, so that owing to the great size of the sac at its junction with the dorsal cup, it does not occupy the center of figure.

Among all groups of Crinoids, the *Cyathocrinidæ* undergo the least amount of change in the course of time. They are represented in the lower Silurian by several genera, and *Cyathocrinus* is the only genus recognized in the Permian. In all intermediate formations, we find Crinoids with five basals, five subradials and five radials, and it is worthy of note that the *Cyathocrinidæ*, in the structure of their vault, bear closer resemblance to the recent Crinoids than almost any other group, and seem to hold an intermediate position between modern and Paleozoic types. If the alternating plates, covering the furrows, could be turned back at the vault by the animal, as the Saumplatten of the arms, then the food groove of these Crinoids was open throughout, as in recent forms. This might possibly have been the case in *Cyathocrinus Iowensis*, but I even doubt it here, as the corresponding plates in other closely related species, though arranged upon the same fundamental plan, present rather an aspect of true vault pieces. The *Cupressocrinidæ* and *Cyathocrinidæ* thus fall naturally into a group by themselves, having the vault supported by consolidating plates, and covered by an immovable arch of small plates.

The next group is one in which of all Paleozoic Crinoids the vault is least known, including *Taxocrinus*, *Forbesiocrinus*, *Onychocrinus*, *Ichthyocrinus*, *Lecanocrinus*, and probably other genera. The *Taxocrinidæ*, for such I will call them, have hitherto been described as being covered with some soft material instead of solid plates, even by Dr. Schultze, though he describes and figures a *Taxocrinus* with a long heavy plated proboscis, which could not have been supported upon a soft skin. * In this group, the plates of the radial series are indented on their upper margins more or less deeply for the reception of a protuberance from the lower side of the succeeding plate. The indentation of the upper margin does not extend throughout the thickness of the plate, and in *Forbesiocrinus*, it is filled by a superficial patelloid plate, which is separately articulated and sometimes anchylosed with the outer margin of the plate above. This peculiarity exists not only in the arm plates, but is conspicuous in the radials, thus producing apparently an articulate structure of the whole skeleton and indicating some degree of flexibility in the body as well as the arms. The interradial portions appear sometimes depressed, and in other cases swollen or bulged out, showing that they probably yielded to a moderate expansion or contraction of the body walls, due to the mobility of the radial parts which likewise involves a flexibility of the summit. I have not been so fortunate to find the summit of any of these genera perfectly preserved, but I feel convinced from what I have observed, that it did not consist of a soft skin. In *Onychocrinus*, the genus which possessed evidently the greatest expansive power, the radial plates are frequently found spread out horizontally, and I have found toward the inner or ventral side of the radials, rather large imbricating plates, to which smaller ones are attached which connect with the plates of the interradial series, and which decrease in thickness inwardly. In several specimens I found the inner part or center of the disc covered by a number of thin, very small plates, whose arrangement could not be made out, but it is highly probable from their size and shape, that they formed a kind of scaly integument which was pliant and flexible, thus facilitating a contraction or expansion of the dorsal portions.

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* I believe Dr. Schultze is mistaken in referring his *T. briareus* to *Taxocrinus* as it lacks all the characteristic features of the genus. Its rather large subra-

The close relationship existing between *Onychocrinus*, *Forbesiocrinus* and *Taxocrinus*, renders it almost certain that their summit was similarly constructed. In *Ichthyocrinus* the peculiarities in the radial portions are less strongly marked, and the genus has no interradial plate, but as it agrees otherwise so nearly with *Taxocrinus* that it is sometimes difficult to separate them, we may feel sure that this *Silurian* genus forms no exception to the general rule, but that its mouth was covered as in other Paleozoic Crinoids.

That the summit in several genera has not been discovered is no proof that it consisted of soft material. During the eighteen years that I collected at Burlington, I obtained several hundred of the most perfect specimens of *Cyathocrinus*,

dials, the large first-radials as compared with the succeeding radials, the single anal plate upon which the heavy proboscis rests, indicate that it belongs to *Cyathocrinus* or some allied genus. His *T. gracilis* may prove to be *Graphiocrinus* or *Scaphiocrinus* (?).

some of them as perfect in most of their parts as if dredged from the ocean, but only two specimens have been discovered in which the summit was preserved, and only a single *Scaphiocrinus.* That this could happen at a locality where even the finest tissues of the most delicate internal organs are preserved, is somewhat astonishing, but yet it can be accounted for by the fact that the pieces which cover the central opening, as also the small alternating plates forming the ambulacral canal, are very thin and that they rest but partly upon the consolidating plates, being thereby rendered insecure and liable to removal by any accident, even with very small force. Moreover the arms of the *Cyathocrinidæ* are generally attached, and the ventral disc thus hidden from view. In specimens in which the arms are destroyed, their destruction almost invariably involved that of the entire ventral side, and so delicate are these parts, that even when the arms are well preserved and so situated as to expose the dome, the plates are nearly always gone, or are found in a confused mass inside the calyx.

I come now to another group in which on the basis of the summit structure, such apparently diverse forms are included that I am under the necessity, very unwillingly, of making a name for it. It includes the families *Actinocrinidæ*, *Platycrinidæ*, *Rhodocrinidæ*, *Melocrinidæ*, and the genera *Schizocrinus*, *Dimerocrinus* and *Macrostylocrinus*, which Rœmer has ranged among the *Cyathocrinidæ*, and I call it provisionally the *Spheroidæ*, from the form of the calyx which is generally somewhat spherical. This large group, embracing over one hundred genera and ranging from the base of the Silurian to the top of the Subcarboniferous, is capable of accurate definition, is easily distinguished, and fortunately the summit is very commonly found well preserved in most of the genera.

The summit is composed of heavy, frequently nodose plates, closely cemented together, so as to form a *free arch* (not supported by consolidating plates), which rests like a hemisphere upon the dorsal cup. The plates of the summit, which at first sight exhibit great apparent diversity, are arranged throughout upon one and the same fundamental plan. Beginning with genera that have but few vault pieces, we find in them the median portion occupied by one large center plate, surrounded by six others, four large ones of equal size, and two smaller ones. The four large plates join laterally and are often placed directly to the center piece. In very large species and sometimes in very old specimens, the plates are separated by small polygonal pieces, but easily recognized by their size. Two of the four plates lie above the interradial series adjoining the anterior ray, the two others, one at each side, are placed between the two lateral rays. The two smaller plates are separated from each other by anal plates or by the proboscis. These seven pieces which I will call the "*apical plates*," are easily recognized by their greater prominence and size in species with comparatively few summit plates and a lateral anal aperture; but their identification is more difficult in species in which a subcentral proboscis is placed between the two small plates, and the whole vault looks like an immense proboscis. In these forms, the four large plates, together with the two smaller ones, are pushed toward the anterior side of the specimen, while the center plate rests with one side against the proboscis.

There are other summit plates following a radial direction, which are either attached to the apical pieces or separated from them by a belt of small polygonal plates. Their number, which varies greatly in different species, depends upon the number of primary arms that spring out directly from the body, no matter how often the arms branch afterward. In species with only two arms to the ray, each ray has two rows of corresponding plates in the dome, one large bifurcating plate forms the upper row, three plates the second row; two of the latter are brachial plates, the third one is an inter-brachial plate separating the two arms. In rays with three arms, there are eight plates in three series. The upper series consist of one large bifurcating plate which evidently corresponds with the third radial of the dorsal side. The second series, corresponding to the secondary radials, is composed of two plates, the plate toward the division with two arms being as large as the plate of the upper series, and the one toward the single arm much smaller. The third series is formed by three brachial and two interbrachial plates. In species with four arms to the ray, both radial pieces of the second series are large, and from each of them there originate two brachial pieces. As a general rule, the summit plates increase in proportion to the number of primary arms of a species in the same manner and on the same principle as the plates of the dorsal side. Every radial from the third radial upward has a corresponding plate on the ventral side, and additional interbrachial plates between corresponding brachial plates above the arms. Therefore in adult specimens, with some little practice, the number of arms can be ascertained nearly as well from the dome as from the dorsal side. The number of vault pieces is enormous in some genera, especially if the radials branch off alternately, as for instance in *Strotocrinus*, where some species have 120 to 180 arms. In looking at a full grown specimen, with its many hundred apparently irregularly arranged vault pieces, one would scarcely expect to be able to discover that this construction, in nearly all the Paleozoic Crinoids, is based upon a definite plan, and that plan the same as prevails below the arms.

That this is the case may be successfully demonstrated in the *young Strotocrinus* which has comparatively fewer summit plates.

The young specimen, in genera with numerous arms, has fewer arm openings than the adult, though both have the same number of arms. This is best observed in the young *Strotocrinus.* Here, the basals, primary radials, first anal and first interradial pieces are comparatively large, while the higher series of interradials are yet absent or but slightly developed. The radials of the higher orders, which in adult specimens form a part of the body, are in young specimens free arm plates, unsupported by any interradial or interaxillary pieces. The arms, therefore, which spring directly from the body in adult specimens, in the young branch alternately right and left after emerging from the body, the spaces between the bases of the branches being subsequently filled by the upward growth of the body, so that the branching, instead of occurring in the free arms, seems to be completed in the body walls. So, for instance, the young *Strotocrinus umbrosus* has at first but four arm openings to the ray, at a later period it is found to have eight, and in the adult state twelve, being a separate opening for each arm.*

The rule, that the number of summit plates increases in proportion to the number of primary arms, holds good with reference to the young specimen. The young *Strotocrinus* has fewer plates than the adult individual (the difference being in proportion to the state of growth), and these are arranged in the same order, and are as easily recognized as those of the simplest species of this group. The apical and principal radial pieces are larger than the intervening interradial plates which, exceptionally in this genus, attain by age the same size as the apical and radial pieces. *The interradial plates* of the vault occupy the intermediate spaces between the radial areas. As their number depends greatly upon the age of the individual, they vary often in the same species. In species with but few arms, we find comparatively few interradials, and those are generally smaller than the other plates. The latter is especially true in young specimens, as also in small species. Sometimes, as for instance in some *Megistocrini* and all *Rhodocrinidæ*, the greater part of the summit is covered by large numbers of small polygonal plates which form regular belts around the apical and radial plates. The species of these genera, though

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*** A young *Strotocrinus*, unless the arms are attached, cannot be distinguished generically from an adult *Actinocrinus proboscidialis*, and as both have the same peculiar ornamentation with the same number of arm openings, they differ but slightly in specific characters. *Actinocrinus proboscidialis* is the typical species of a small group of beautifully ornamented Crinoids, and is evidently the forefather of all *Strotocrini*, which idea seems to be further confirmed by the geological succession. The former group occurs only in the *Lower*, and *Strotocrinus* only in the *Upper* Burlington limestone.**

being comparatively of large size, have generally but two primary arms, and consequently for each ray but one radial dome plate which is here placed at some distance from the arm bases. In the *adult Megistocrinus* the radial as well as apical plates are extremely large and stand forth conspicuously, and each one separately, among the surrounding minute polygonal pieces. In the *young Megistocrinus*, however, and in the *Rhodocrinidæ* generally, the apical pieces and the radial plate are placed side by side, being surrounded by the polygonal plates. The form and size of the principal summit plates, the distribution and number of the interradial pieces, afford most excellent characters for distinguishing many genera. In *Agaricocrinus*, all apical and radial pieces are large and tuberculous, the few interradials are small. In *Dorycrinus*, the center plate and first radials are spiniferous or nodose. In *Amphoracrinus*, the four large apical pieces are spiniferous or tuberculous, the radials nodose. In *Platycrinus* and *Hexacrinus*, the apical plates are very prominent, often tuberculous, the radial portions are somewhat constructed like the rows of small alternating plates of the *Cyathocrinidæ*. In *Batocrinus*, all summit plates are nodose and almost of equal size.

The apical plates can be distinguished in other groups as well as in this. They surmount the vault of *Synbathocrinus* and *Cyathocrinus*, cover the central opening of the Blastoids, and can be traced in many of the Cystideans. This, with the further fact that they are so largely developed in young specimens, that they cover and protect some of the most important organs of the inner cavity, shows their great importance, and leads us to infer that they were the first solid parts developed on the ventral side in young Crinoids. The center piece corresponds evidently with the basals of the dorsal side, the surrounding plates to the subradials (the two smaller plates, separated by the anus forming together one large one), which on the other hand were undoubtedly the first developed parts of the dorsal side, and the parts which are the most highly developed in the Cystideans.

The above groups, representing the three principal plans upon which the vault is constructed, embrace, according to my views, not only all those Paleozoic genera which were supposed to be covered by a membranous surface, but nearly all Paleozoic Crinoids that are known. There are some few genera, as for instance *Eucalyptocrinus*, with a very peculiar superstructure at the ventral side, whose affinities I have not been able to determine. There is the genus *Calceocrinus* which differs so widely from all other known Crinoids by its distinct bilateral symmetry and unique structure, that it forms evidently a very distinct group by itself. There may be still others, differing in their summit structure from the general plan; but I have yet to discover a single Paleozoic genus in which a special oral aperture has been identified, or in which the existence of a solid vault has been disproved, or cannot be traced by analogy. Thus it may be possible that the solid vault was essential under the conditions which prevailed in the earlier geological ages.

Closely related as the recent Crinoids are to their Paleozoic ancestors in some points, the solid vault of the latter cannot in the remotest degree be homologized with the soft peristome of the former. The solid dome forms, as I think I have proved, a continuation of the radial and interradial series of the dorsal side and serves merely as a covering and protection for the organs underneath. It is in every sense of the word aboral and forms a part of the abactinal system, which being already reduced in the *Pentacrinidæ* and *Comatulidæ* to a narrow tentacle furrow, recedes in Paleozoic Crinoids one step further and disappears within the solid walls of the body. The actinal system here consists externally only of the arm furrows, whence it continues underneath the vault. These Crinoids therefore are evidently of lower development and belong to an inferior type.

The ventral peristome of the recent Crinoids serves as a madreporic apparatus, introducing the necessary water for respiration. It is capable of expansion, and does expand when water or food is introduced into the inner cavity, and contracts when refuse matter is expelled. These are functions which the solid vault could not have performed, and there must have been consequently important modifications in the internal economy of these animals. Comparing the large size of the calyx of the *earlier* Crinoids with the small cup and large long arms of the *recent* types, we find in the former an approach to the *Cystideans*, as also a striking resemblance to the nascent *Pentacrinus* before its arms are fully developed. In the older forms, the radial plan is almost overshadowed by the bilateral arrangement of the vault, which reminds of the bilateral symmetry in the earlier stages of other Echinoderms. All these facts tend to prove, that the *Paleozoic Crinoids*, embracing therein all *true Crinoids in which the actinal side is closed*, represent the young stage of growth of the living types. They bear evidently the same relation to the *Pentacrinidæ* and *Comatulidæ* as the *Perischoechinidæ bear to the Echini, as the Cystideæ and Blastoideæ bear to the Paleozoic Crinoids.* They unquestionably form a *distinct group* of Crinoids, and I therefore propose for it, from the fact that its representatives lived almost exclusively in Paleozoic times, the name: "*Paleocrinoidea*" *as a suborder of the Crinoids.*

Whether *Encrinus*, *Apiocrinus* and allied genera of the Jurassic time are to be brought within this suborder, depends upon the construction of their vault, which cannot at present be determined. Should they prove to have a solid dome they would be included here, and this might detract slightly from the technical exactness of the name *Paleocrinoidea.* Still as its characteristic types were so prevalent and constituted so important a part of the life of Paleozoic ages and the Mesozoic forms are comparatively so insignificant in variety and abundance, the term would nevertheless be significant and appropriate.

I shall not attempt to separate the *Paleocrinoideæ* into families, as I think our present knowledge is hardly sufficient for such a work, but I feel convinced that it must be based mainly upon the diversities in the structure of the vault, not upon the construction of the dorsal cup, nor upon the structure of the arms or column, upon which former authors have founded such divisions.

The discoveries which have been made within the last few years, both in recent and extinct Crinoids, are really wonderful, and lead us to expect large additions to our knowledge in the future. I observe in the February number of this Journal, that Professor Thomson has discovered at great depth two new genera of *Apiocrinidæ,* one of them resembling in superficial structure the genus *Poteriocrinus.* This may throw new light upon the physiology of the extinct types and solve some of the questions herein suggested. Other discoveries will follow. The labors of the Zoologist will supplement the researches of the Paleontologist and through their properly united efforts, we may hope in time to comprehend the structure of the *Paleocrinideæ* almost as perfectly as if they were yet living in our oceans.

ART. XXV.—*On some Phenomena of Binocular Vision;* by JOSEPH LECONTE.

X. *The structure of the crystalline lens and its relation to Periscopism.**

THE following thoughts were suggested by the recent memoir of Dr. Ludimar Hermann "On the passage of luminous pencils obliquely through lenses, and on a related property of the crystalline lens of the (human) eye,"† in connection with my own recent publication "On the comparative physiology of Binocular Vision."‡

It is well known that the crystalline lens of the mammalian eye increases in density and refractive power, from the surface to the center; so that it may be regarded as composed of ideal concentric layers, one within another increasing in density and in curvature until the central nucleus becomes a very dense and highly refractive spherule.

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* Read before the National Academy of Sciences, April, 1877.

† Archives des Sciences, vol. lii, p. 66. ‡ This Jour., vol. ix, p. 168, 1875.

Evidently this structure must have some important use in vision or it would never have been formed; but the question of its design has never been satisfactorily settled. It is usually regarded as intended to correct spherical aberration. It certainly is useful in this way, *when the pupil is greatly expanded.* But in strong light, when the pupil is greatly contracted and therefore only central rays reach the retina, *correction is not needed,* because, even in a homogeneous lens, *aberration,* under these circumstances, is *inappreciable.* It is natural, therefore, to cast about for some other purpose subserved by this very curious and universal structure.

Very recently Dr. Hermann (loc. cit.) has discovered another optical property conferred upon the lens by this structure—a property which he regards as of great importance in perfect vision, and which, therefore, he thinks, entirely explains the design of the structure. It is the property of *forming images of objects lying on the margins of the field of view, far more perfect than could be formed by a homogeneous lens* of the same focal distance. And since, as he supposes, perfect images of marginal objects necessitates distinct vision of these objects, he calls a lens having this structure *periscopic.*

By mathematical discussion he shows that, in a homogeneous lens, while the central rays *from radiants near the middle of the field of view*—i. e., of pencils nearly parallel with the axis of the lens—are brought to a perfect focal point, the central rays, from *marginal radiants*—i. e., of very oblique pencils—form crossing caustic lines. The refraction in the former case is *stigmatic,* in the latter *astigmatic.* Therefore the picture formed by such a lens is distinct in the central parts and very indistinct on the margins. Now this well known defect of a homogeneous lens Dr. Hermann shows is certainly in a great measure, probably entirely, *removed by the structure peculiar to the crystalline lens.* For in the case of a lens composed of concentric laminæ increasing in density and curvature to the center, the astigmatism of oblique pencils is greatly diminished, and if the laminæ be infinitely thin, probably entirely removed. The picture formed by such a lens would therefore be perfect in all parts, even to the extreme margins. *The crystalline lens, therefore, by its structure is endowed with the property of forming distinct images of objects lying even on the extreme margins of the field of view—of forming perfect images on all parts of the retinal screen even to the extreme anterior margins.* It is this structure, according to Dr. Hermann, which gives the eye its enormous field of view, compared with that of optical instruments. This then is the purpose of this structure. *It gives periscopism to the eye.*

Such is a brief statement of Dr. Hermann's discovery, and his deductions therefrom. This discovery I regard as very important, but his deductions in regard to periscopism of the human eye cannot be received without important modifications. For it can be shown that so far as periscopism is concerned, the peculiar structure of the lens is of little, if any, value in man, *for want of a corresponding suitable retinal structure.*

In order to show this, it is necessary carefully to distinguish two kinds of indistinctness of vision, viz: that which results from *indistinctness of the retinal image*, and that which results from *imperfect perception* of the image. The former has its cause in the properties of the lens, the latter in the organization of the retina. We may have a very perfect perception of an imperfect image, and on the other hand we may have so imperfect a perception of an image that we cannot tell whether it is perfect or not. If, for example, I hold the point of my pen very close to one eye (shutting the other), and look at the sky, the pen point is very indistinct, because the retinal image is indistinct; but my perception is perfect. *I can observe with great accuracy the exact degree of indistinctness.* This is an example of one kind of indistinctness of vision. But if I hold my pen far to one side, on the extreme verge of the field of view, say 90° from the direction of the optic axis, the pen is again indistinct, far more so than before, but from an entirely different cause, viz: *imperfect perception* of the retinal image. My perception, in fact, is so imperfect that I cannot tell whether the image is distinct or not. This is an example of the other kind of indistinctness of vision.

Now of these two kinds of indistinctness, the latter is by far the greater. Objects on the margin of the field of view are perceived as objects, and nothing more; their form cannot be distinguished—they attract attention, but we must turn the optic axis on them or near them in order to tell what they are. For example, held at arm's length and 90° from the usual line my pen is seen only as an elongated object; at 60° the shape is still indistinguishable—neither the point, nor the hole through the back, can be seen at all, though projected against a bright sky. Only at 30°–40° these begin to be distinguished. Even within a few degrees of the optic axis the *perception* of form is still very imperfect. In this case, however, the indistinctness is wholly the result of imperfect perception, not of imperfect image. I cannot perceive whether the image is perfect or imperfect—whether the outlines are blurred or sharply defined.

It is evident, therefore, that the retina of the human eye is so organized (and as I have shown in my previous article,* it is important that it should be so organized), that the perception of its images, good or bad, is most perfect in the central spot, and thence becomes less and less perfect toward the anterior margin, where it finally becomes extremely imperfect. Evidently, therefore, with this extremely imperfect marginal perception, extremely perfect marginal images would be entirely useless. *Periscopic structure of the lens is useless because periscopic perception of the retina is wanting.*

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* Loc. cit.

True periscopism, i. e. the power of distinct vision over a wide field without changing the direction of the optic axis, is therefore a product of two factors, viz: 1st, a periscopic property of the *lens*, i. e. of *making* distinct marginal as well as central images; 2d, a periscopic property of the *retina*, i. e. of distinctly *perceiving* marginal as well as central images. Now, Dr. Hermann has left out the second factor, and thus identified periscopism of the lens with periscopism of the eye.

I think it quite certain, therefore, that the property of making distinct marginal images, and therefore the characteristic lens structure, *in so far as it subserves this purpose*, is useless in *man*. Yet it seems equally certain that this property is a very important one. Where then shall we seek its use, and what is its significance in man? I believe we must seek its use in the lower animals, where it originated. In man it must be regarded as an example of *a structure which has outlived its usefulness.*

We have already shown in our last paper (p. 170), that true periscopism, or distinct vision over a wide field, is a necessary condition of safety in many of the lower animals. In accordance with the law of evolution, therefore, an ocular structure, suitable for this purpose, must be gradually formed and perfected. This ocular structure, as we have just seen, consists of two parts, a *lens* structure to produce perfect marginal images and a *retinal* structure to produce equal perception of all images, central and marginal. Both of these were developed in the highest degree in many of the lower animals, as for example in the ruminants. But in the highest animals, and especially in man, as we have shown in the paper referred to, this equal distribution of perception is inconsistent with fixed attention and thoughtful observation, and therefore with the development of the higher faculties of the mind. The uses of distinct marginal perception, viz: breadth of distinct view, are sacrificed to the higher uses of distinct central perception alone, viz: fixed thoughtful attention to the object regarded alone. Thus with the development of the *central spot* of the retina, *distinct marginal perception* is lost; because the uses of the latter are inconsistent with the higher uses of the former. But the other factor of periscopism, viz: the property of forming distinct marginal images, is retained by inheritance; because though no longer useful in this way, it is in nowise hurtful and may even be useful in other ways.

But I have also (loc. cit.) shown the close relation between the development of the central spot and the consequent loss of periscopism, and the development of true binocular vision. Hence it is evident that, in going up the vertebrate scale, just in proportion as the central spot is developed, and the position of the eyes is adapted for binocular vision, the characteristic structure of the lens, in so far as it is designed to produce perfect marginal images, becomes useless. There may be, however, and probably are, other uses, (e. g. correction of aberration), which this structure subserves and which would tend by natural selection to keep up the structure. It would be extremely interesting in this connection to compare the lens of the human eye with that of the eye of the ruminants. In so far as it subserves the purpose of periscopism the characteristic structure ought to be less marked in the human eye, since its retention is due to inheritance alone, and not to natural selection. If it is not less marked there would be strong reason to suspect that periscopism is not the most important purpose of this structure.

Berkeley, Cal., Jan., 1877.

ART. XXVI.—*On Ethylidenargentamine-ethylidenammonium Nitrate;* by W. G. MIXTER. *Contributions from the Sheffield Laboratory of Yale College.* No. XLIX.

LIEBIG, in his researches on aldehyde,* examined the precipitate obtained by mixing concentrated solutions of aldehyde-ammonia and silver nitrate. His analysis of it shows an atomic relation of silver 1, carbon 4, and hydrogen 11. He failed to estimate nitrogen and hence did not obtain a formula, but concluded from the deportment of the compound with acids and alkalies that it contained aldehyde, ammonia and nitric acid.

I have not succeeded in getting a good product for analysis by mixing simple aqueous solutions of aldehyde-ammonia and silver nitrate. Decomposition began before the substance could be washed with alcohol. This decomposition is, however, prevented, by using ammoniacal solutions. The substance is soluble in one and one-half parts, or less, of concentrated ammonia water, and is still less soluble in pure water. In the first experiment with ammoniacal solutions, the ammonia was rapidly removed by a blast of air, and from equal weights of aldehyde-ammonia and silver nitrate, two crops of very small white crystals were obtained, which were washed with alcohol, and dried over oil of vitriol. The carbon and hydrogen were determined by burning with lead chromate, the nitrogen by Schiff's method with copper oxide and displacement of air by a slow stream of carbonic acid, and the silver by simple ignition. The following results were obtained from the two crops above mentioned:

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* Liebig's Ann., xiv, 147.

	1st crop.	2d crop.	Mean.	Atomic ratio.	Calculated for $C_4H_{10}N_3O_3Ag$.
Carbon	18·32	18·33	18·33	3·9	18·75
Hydrogen	4·31	4·16	4·23	10·8	3·91
Nitrogen	16·63	16·65	16·64	3·	16·41
Silver	42·06	41·99	42·03	1·	42·18
Oxygen			18·77	3·	18·75
			100·00		100·00

These results give a formula different from $NO_3Ag\,2(C_2H_3ONH_4)$, which is given in Watts' Dictionary, vol. i, p. 108, as probably representing the substance. Taken together with Liebig's analysis, they also indicate that the same body is formed in both aqueous and ammoniacal solutions.

$C_4H_{10}N_3O_3Ag$ differs from two equivalents of aldehyde-ammonia and one equivalent of silver nitrate by two molecules of water, thus: $2(C_2H_4ONH_3)+AgNO_3-2H_2O=C_4H_{10}N_3O_3Ag$. This view of the chemical process is supported by the reactions of aldehyde with benzamide and aniline, in which water separates, and also by the following experiment: 29·2 grams of a mixture of silver nitrate and good crystals of aldehyde-ammonia, in the proportion of one equivalent or 17· grams of the former, to two equivalents, or 12·2 grams of the latter, were dissolved in 40 c. c. of concentrated ammonia-water. The solution was evaporated in a weighed dish, first by a blast from a laboratory bellows and finally over oil of vitriol until the weight was constant. The residue weighed 25·445 grams. The weight, according to the above formula, should have been 25·600 grams. The difference of 0·155 grams between the experimental result and theory may be ascribed to the slight decomposition the substance had undergone in drying, which was shown by the small black residue it left when treated with ammonia-water.

When an ammoniacal solution of aldehyde-ammonia and silver is evaporated at 20° to 30°, hydrous monoclinic transparent crystals separate, which do not change rapidly on damp days, but become opaque with loss of water in dry weather. Together with the hydrous crystals, small poorly defined triclinic crystals form which do not become opaque in dry air. The latter are transparent and colorless, or more frequently have a resinous tinge. Dr. E. S. Dana has studied the crystalline form of both the hydrous and anhydrous crystals, and gives his results in the following paper, Art. XXVII. The hydrous crystals can be picked out before losing their luster if the atmosphere is damp, and the anhydrous crystals are easily distinguished after the former have become opaque. The following results were obtained on good monoclinic crystals which had been dried over oil of vitriol, and on transparent anhydrous crystals:

	Monoclinic dried crystals.	Triclinic crystals.	Calculated for $C_4H_{10}N_3O_3Ag$.
Carbon	18·55	18·62	18·75
Hydrogen	4·08	4·12	3·91
Nitrogen	16·58	16·64	16·41
Silver	42·03	41·97	42·18
Oxygen			18·75
			100·00
Specific gravity,	2·13	2·28	
Melts with rapid decomposition at	130°–135°	125°–130°	

To determine whether the monoclinic substance lost any ammonia on drying, nearly two grams of crystals, not entirely free from the triclinic body, were heated to 100°, in air which traversed a caustic potash drying tube before reaching the substance and then passed a weighed tube filled with fragments of caustic potash. The substance lost in weight exactly what the latter tube gained, and the water thus estimated corresponded to 4·20 per cent. The following results were obtained by drying well selected monoclinic crystals in a desiccator at 20° to 30°:

0·383	gram lost	4·28	per cent.
0·343	" "	4·26	"
0·437	" "	4·23	"
1·0504	" "	4·24	"

After the 0·383 gram had obtained a constant weight in the desiccator it was exposed for half an hour to 60° without further loss; in three quarters of an hour at 100° the loss increased 0·0025 gram and the crystals had become brown. These water determinations lead to the troublesome formula for the monoclinic hydrous crystals, of $8(C_4H_{10}N_3O_3Ag)+5H_2O$, which represents 4·21 per cent of water.

Both kinds of crystals are soluble in water, very soluble in ammonia water, almost insoluble in alcohol, sparingly soluble in ammoniacal absolute alcohol, and both give a silver mirror when their aqueous solutions are heated, and but a trace of silver remains in solution after continued boiling. With hot potash solutions both forms give the same odor that is perceived when aldehyde-ammonia is treated with potash. Dilute acids set aldehyde free, and warm oil of vitriol evolves nitrogen peroxide fumes. Both turn brown at 100°, the monoclinic crystals remain brittle, but the triclinic substance becomes gummy at

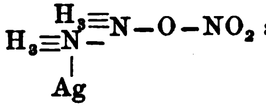
100° after some time. The triclinic crystals decompose rapidly a few degrees lower than the monoclinic. Both kinds appear to be permanent in dry air. On recrystallizing the monoclinic variety some triclinic crystals appear, and the triclinic form yields on recrystallization some monoclinic crystals.

As to the constitution of the bodies their reactions make evident that they contain the ethylidene and nitro groups. They are plainly analogous to the ammonio-silver nitrate, which crystallizes from a mixture of silver nitrate with excess of ammonia water as all contain (exclusive of crystal water) 3 atoms of nitrogen and 3 atoms of oxygen to 1 of silver. We may therefore, regard them as amines, and may show their relation to ammonia-silver nitrate as follows:

$$\left.\begin{array}{l} H_3N \\ H_3N \end{array}\right\} AgNO_3 \qquad \left.\begin{array}{l} CH_3-CH=NH \\ CH_3-CH=NH \end{array}\right\} AgNO_3$$

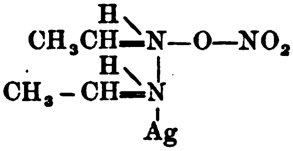
In accordance with the requirements of the now received theories, these bodies may be formulated as substituted ammonium nitrates, viz:

$H_4\equiv N-O-NO_2$, ammonium nitrate.



$$\begin{array}{l} \quad\;\; H_3\equiv N-O-NO_2 \\ H_3\equiv N- \\ \qquad\;\; | \\ \qquad\;\; Ag \end{array}$$

argentamine-ammonium nitrate.



ethylidenargentamine-ethylidenammonium nitrate.

Art. XXVII.—*On the crystalline form of the hydrous and anhydrous varieties of Ethylidenargentamine-ethylidenammonium Nitrate;* by Edward S. Dana.

A. *Hydrous Ethylidenargentamine-ethylidenammonium Nitrate.*

The hydrous variety of ethylidenargentamine-ethylidenammonium nitrate, described by Professor Mixter in the preceding article, crystallizes in the *monoclinic* system. The observed planes (see figs. 1, 2) are as follows:

c (001), *d* (111), *g* ($\bar{1}11$), *e* (011), and rarely *b* (010).

From the measurement of a considerable number of crystals the following were obtained as the fundamental angles:

$$\begin{array}{l} c\,(001) \wedge e\,(011) = 69^\circ\ \ 2' \\ c\,(001) \wedge d\,(111) = 78^\circ\,35' \\ d\,(111) \wedge d'(1\bar{1}1) = 60^\circ\,50' \end{array}$$

From these angles the elements of the crystals were calculated, viz:

$$\overset{|}{c} : \bar{b} : \breve{a} = 4{\cdot}32645 : 1{\cdot}65788 : 1{\cdot}00000$$

$$\beta = 89^\circ\,43'\,52''$$

Other important angles, calculated from the same data, are as follows:

$$\begin{array}{lcl} c\,(001) \wedge g\,(\bar{1}11) & = & 79^\circ\ \ 2' \\ g\,(\bar{1}11) \wedge g'(\bar{1}\bar{1}1) & = & 60^\circ\,56' \\ d\,(111) \wedge g\,(\bar{1}11) & = & 114^\circ\,17' \\ d\,(111) \wedge e\,(01\bar{1}) & = & 66^\circ\,18' \\ g\,(\bar{1}11) \wedge e\,(01\bar{1}) & = & 65^\circ\ \ 5' \\ d\,(111) \wedge e'(0\bar{1}\bar{1}) & = & 122^\circ\,56' \\ g\,(\bar{1}11) \wedge e'(0\bar{1}\bar{1}) & = & 122^\circ\,48' \\ d\,(111) \wedge b\,(010) & = & 59^\circ\,35' \\ g\,(\bar{1}11) \wedge b\,(010) & = & 59^\circ\,32' \end{array}$$

The measured angles agreed quite closely with the calculated angles when the character of the planes was such as to admit of satisfactory observations. This will be seen from the following examples, being the angles measured on different crystals for $d \wedge d'$ and $c \wedge c$:

$d \wedge d' = 60^\circ 50'$, $60^\circ 47'$, $60^\circ 46'$, $60^\circ 47'$, $60^\circ 51'$, $60^\circ 52'$, $60^\circ 50'$, etc.

$c \wedge d = 78^\circ 35'$, $78^\circ 39'$, $78^\circ 40'$, $78^\circ 33'$, $78^\circ 34'$, $78^\circ 40'$, $78^\circ 38'$, $78^\circ 36'$, etc.

In many cases, however, the planes were by no means satisfactory, being generally polished and yet far from smooth, and hence the reflections given by them were more or less uncertain. The planes g, g' were quite uniformly striated, and hence the measurements made upon them were always unreliable. The following angles were all obtained from a single crystal; the wide variations from the calculated angles observed in some cases are due to the cause named:

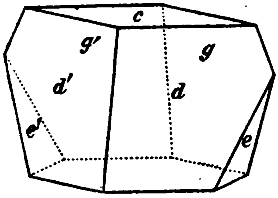
$$\left\{\begin{array}{l} c \wedge d = 78^\circ\,27' \\ c \wedge d' = 78^\circ\,38' \end{array}\right. \qquad \left\{\begin{array}{l} d \wedge g = 114^\circ\,12' \\ d' \wedge g' = 114^\circ\ \ 7' \end{array}\right. \qquad \begin{array}{l} d \wedge d' = 60^\circ\,46' \\ g \wedge g' = 60^\circ\,46' \end{array}$$

$$\left\{\begin{array}{l} c \wedge g = 78^\circ\,10' \\ c \wedge g' = 78^\circ\,30' \end{array}\right. \qquad \left\{\begin{array}{l} d \wedge c = 65^\circ\,52' \\ d' \wedge c' = 66^\circ\,23' \end{array}\right. \qquad \left\{\begin{array}{l} g \wedge e = 65^\circ\,41' \\ g' \wedge e' = 66^\circ\,33' \end{array}\right.$$

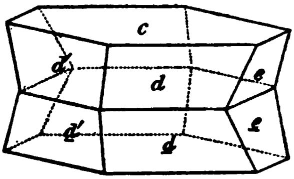
$$\left\{\begin{array}{l} c' \wedge e = 69^\circ\ \ 3' \\ c' \wedge e' = 69^\circ\ \ 2' \end{array}\right. \qquad \left\{\begin{array}{l} d \wedge e' = 122^\circ\,51' \\ d' \wedge e = 122^\circ\,30' \end{array}\right. \qquad \left\{\begin{array}{l} g \wedge e' = 122^\circ\,57' \\ g' \wedge e = 123^\circ\,33' \end{array}\right.$$

The crystals examined were quite small, averaging from one to two millimeters in length. The are generally rhombic

1.



2.



(fig. 1) at one extremity, and hexagonal in outline on the other; occasionally, however, from the extension of the clinodomes they take the form of hexagonal tables (fig. 2). The hemihedral character of the crystals, shown in the figures, is a marked feature which they all possess. No trace of either of the missing pyramids or clinodomes was in any case discovered; a few isolated crystals of apparently holohedral development were without exception found by optical means to be twins, though showing no reëntrant angles. Other twins had the form of fig. 2. The twinning-axis is here a normal to the basal plane.

The cleavage is highly perfect parallel to the base (*c*), and the crystals have a pearly luster on this face.

The examination of the optical properties of the crystals proves that, though the angle of obliquity is small (89° 44'), they unquestionably belong to the *monoclinic* system, and, on the other hand, that they are not triclinic.

A natural crystal, or still better a cleavage section, viewed in the polariscope in a direction normal to the basal plane (*c*), shows the biaxial interference figures most satisfactorily. The axes, however, do not lie in the center of the field, but slightly on one side in the direction of the pyramids *d*, *d'*; thus showing that the plane of the optic-axes is not quite normal to the base. The *horizontal* dispersion is also very strongly marked.

A section cut parallel to the clinopinacoid and examined in the polariscope of Groth, shows that the acute bisectrix for blue rays makes an angle of 8° with a normal to the base (*c*), being inclined forward (see fig. 1) toward *d*, while the same angle for red rays is 5½°.

The apparent optic-axial angle in air was obtained with considerable exactness:

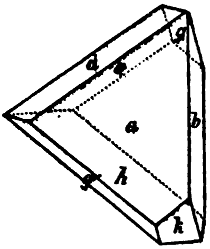
2E=68° 23' for red rays, =67° 30' for blue rays. The ordinary dispersion is consequently $\rho > v$; the dispersion of the bisectrices, on the other hand, $v > \rho$. The character of the double refraction is *negative*.

The twins (see fig. 2) gave interference figures of great beauty, both sets of axes being visible, situated symmetrically on either side of the medial line. The apparent angle between the two axial planes, measured in the usual way, was found to be 31° for blue and 25° for red. The true angles corresponding to these, obtained with the stauroscope, are 16° and 11° respectively. The first-mentioned angles, however, are not sufficiently accurate to serve for the calculation of one of the indices of refraction.

B. *Anhydrous Ethylidenargentamine-ethylidenammonium nitrate.*

The crystals of the second, or anhydrous, variety of this compound belong to the *triclinic* system. Unfortunately the material which Prof. Mixter has thus far been able to put into my hands has been much too imperfect to allow of exact determination. The crystals are small and the planes uniformly rough and uneven, so that the measured angles with an occasional exception cannot be relied upon within less than 30′.

3.



The crystals are quite uniform in habit, and figure 3 represents as closely as possible the common form. The crystal is placed in the position given in order to exhibit the close approximation to the *monoclinic* form. *e*, *g*, *h* are planes of the lower side, and *a′* is opposite *a*.

The angles measured on one crystal are as follows:

$a\,(100) \wedge d(1\bar{1}1) = 57°\,20'$ $a\,(100) \wedge g(\bar{1}11) = 65°\,10'$

$a'(\bar{1}00) \wedge h(\bar{1}\bar{1}\bar{1}) = 58°\;\;2'$ $a'(\bar{1}00) \wedge e(\bar{1}\bar{1}1) = 64°\;\;4'$

$g\,(\bar{1}11) \wedge e(\bar{1}\bar{1}1) = 65°44'$

These angles point to a form having an obliquity in a vertical direction of about 5°, but very slightly inclined in a horizontal direction. The measurements for a (100)$\wedge$$b$ (010) gave in the best case 90° 10′, and again 90° 20′. The variation from 90° is here within the possible error of observation, owing to the imperfect character of the planes; the question was not decided, consequently, until a stauroscope examination showed that the plane of vibration for the light was not normal to b (010), but made an angle of about 18°, thus proving the *triclinic* nature of the crystals.

The measured angles, as has been stated, are not sufficiently reliable to give the axial ratio calculated from them any especial value; the approximate values of the axes are, $\acute{c}=1{\cdot}45$, $\bar{b}=1{\cdot}93$, $\breve{a}=1$. The hemihedral character of the crystal figured is true of all the crystals, and the examination in the stauroscope failed to show any evidence of twinning. The crystals were not suited for any further optical examinations.

ART. XXVIII.—*On the relations of the Geology of Vermont to that of Berkshire;* by JAMES D. DANA.

[Continued from page 140.]

CONCLUSIONS AS TO THE RELATIONS OF VERMONT AND BERKSHIRE GEOLOGY.

THE conclusions, which flow from the fact, illustrated in the two preceding numbers of this Journal, that the limestone areas of Vermont and Berkshire are geologically one, may be presented under the following heads:

1. Chronological conclusions: or the equivalence and age of the formations.
2. Lithological conclusions.
3. Orographic conclusions.

And, as a sequel to this discussion, I propose, next, to present stratigraphical facts bearing on the geological relations between the area which has been under consideration and the country lying to the southward and eastward of it, in Connecticut and New York.

I. CHRONOLOGICAL CONCLUSIONS: OR THE EQUIVALENCE AND AGE OF THE FORMATIONS.

1. *Age of the Limestone series as a whole.*—From the facts brought forward it is manifest that the limestone, schists and quartzyte, making up the limestone series of Vermont and Berkshire, are *continuous* formations, and that they are *conformable* throughout. Hence we have proof that the conclusions deduced for Vermont, from Mr. Wing's discoveries, are true also for Berkshire: namely, that—

(1.) The limestone series is *made up wholly of Lower Silurian formations;* that is, of formations not older than the Primordial or Cambrian, nor newer than the Cincinnati or Hudson River group.

(2.) All these formations were upturned and metamorphosed together at one mountain-making epoch, no epoch of disturbance having intervened; and that upturning occurred after the laying down of the most recent of the formations in the series.

2. *Age of the Taconic slates, and of the limestone immediately adjoining.*—The Taconic mountains of western Berkshire are a direct continuation of the "Great central slate-belt" of Vermont. The two make one range and one rock-formation, and consist of the same kinds of rocks similary upturned. They are alike also in dividing off a western band of limestone from the main limestone area—that extending through West Cornwall in Vermont, and that of Hillsdale, Copake and Millerton, in New

York. In Vermont the Taconic slates (those of the central slate-belt) *overlie* the adjoining limestone in one or more synclinals, as plainly shown in Mount Dorset, Danby Mountain, Equinox Mountain, Spruce Peak in Arlington, and Mount Anthony in Bennington; and in Berkshire they have the same position, as observed in Graylock and Mount Washington. Hence in both States *the Taconic slates overlie, or are younger than, the adjoining limestone.*

In Vermont, as Mr. Wing has shown, the limestone nearest the slate contains, in several places, Trenton fossils (*Trinucleus*, etc.), and at West Rutland, Chazy fossils (*Maclurea*, etc.) if not also Trenton; and the slates are, therefore, as has been already stated, *younger* than the Trenton limestone of that region and belong probably to the Hudson River or Cincinnati group. If this be true in Vermont, the Taconic range in Berkshire, since it is part of the same slate-belt, consists of rocks younger than the Trenton, and is therefore either of the *Upper Trenton or of the Hudson River or Cincinnati group.*

It may be questioned whether the Graylock Spur should be included with the Taconic range, since it stands to the east of it. But the resemblance in its rocks to those of the Taconic range, coupled with its position stratigraphically *above the adjoining limestone*, just as in Mount Anthony, Equinox Mountain, Mount Eolus and other peaks in the slate-belt of Vermont, make it almost certain that the age of one is the age of the other, as first observed by Emmons.

The Berkshire *limestone* of the band adjoining the Taconic range is mostly, if not wholly, non-magnesian, like that of Vermont. Hence its constitution, as well as its position, makes it altogether probable, that it is Trenton or Chazy, as in Vermont. The limestone *west* of the Taconic range in Hillsdale, Copake and farther south, must also be Trenton or Chazy since this is true for that similarly situated in Vermont; and, moreover, it is the west side of one and the same synclinal flexure, the limestone on the east side of the Taconic range passing beneath and coming up again on the west side.

3. *The Limestones and Schists of the Eastern half of the limestone area.*—Like the Taconic slates to the westward, these more eastern rocks in Berkshire are a continuation of those north of them in Vermont. The quartzyte is not all in one range in either State; but, whether in one or several ranges, it is alike from north to south in belonging especially to the more eastern part of the limestone area. Hence whatever is true of the age of the quartzyte in one State is almost certainly true in the other.

Further, whatever the range of age in the more eastern of the limestones of Vermont, the same is the probable range of that in Berkshire and farther south. Like the Vermont limestone then, the Berkshire limestone of the middle and eastern half of the area may include the Calciferous, Quebec, Chazy and Trenton formations, and perhaps also the Primordial; but, since there are no fossils to fix the precise age, the areas of these different formations in Berkshire cannot be separately distinguished.

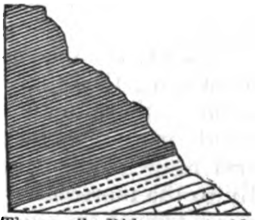
4. *The age of the Quartzyte formation, and its relation in position to the adjoining limestone.*—The quartzyte formation includes, as has been explained, strata of quartzyte and schists—sometimes one, and sometimes the other, predominating. The special age of the formation is in doubt, equally with that of the eastern limestones. There may be quartzytes of different periods of the Lower Silurian; and so with the schists. The question of age can be positively answered only by the discovery of decisive fossils in the quartzytes of Vermont; and so many imperfect forms have already been brought to light (besides the unsatisfactory worm-burrows, and Fucoids or worm-tracks) that we may feel sure the future will clear away the doubts. A word is added beyond (p. 207) on two of the forms thus far discovered.

One important point—the position of the quartzyte with reference to the associated limestone—is well illustrated in Berkshire. Mr. Wing, in his explanations of the Vermont sections (pp. 410, 411 of the last volume of this Journal), makes this limestone to *overlie* the quartzyte, and to be the equivalent of the "subcrystalline limestone" which overlies the Red Sand-rock on the west side of the limestone area—the quartzyte being in his view the same rock with the Red Sand-rock. It is to be noted, however, that the sections themselves do not indicate whether the limestone is overlying or underlying, and may be explained as well on one supposition as the other.

In Berkshire, beyond all reasonable doubt, *the eastern quartzyte formation overlies the adjoining limestone.*

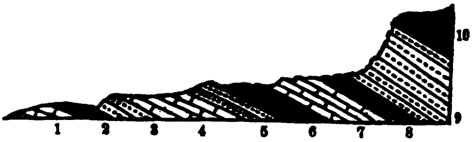
The most distinct and positive proof of the superposition of the quartzyte over limestone that I have observed is that afforded by sections either side of Konkaput Valley—a locality brought to my attention, as I state in my memoir of 1872–3, by Dr. R. P. Stevens. The figures of the sections of Devany's

19.



Three-mile Ridge, west side of Konkaput Valley.

20.



Devany's Quarry, east side of Konkaput Valley.

Bluff and Three-mile Ridge, which face one another on opposite sides of the valley, are here repeated from page 45 of this volume. In each of the sections, quartzyte strata and overlying schists of great thickness rest on the limestone which outcrops in the valley. The dip is small (8°–25°, p. 46). The limestone is plainly at the bottom; and *it is stratigraphically* so, unless there has been a flexing of the strata and an overturned fold at the place. Nothing in the region suggests that there has been such an overthrow; the facts, on the contrary, prove the flexure which the strata have undergone to be a gentle one. As has been stated, the two ridges stand opposite one another, not quite a mile apart. In the eastern, the dip is 20°–25° to the northeastward; in the western, about the same to the northwestward. The series of rocks from below upward, limestone, quartzyte, schist, of one side, is repeated in the other, and the schist of the west side has a thickness of several hundred feet like that of the east. All the conditions are those of a low anticlinal spanning the valley; and one whose axis dips gently northward, and whose sides flare southward or southward and eastward. The valley south of Devany's Bluff widens much to the eastward and has its lakes with limestone about them.

Besides this, the rocks of the gentle anticlinal are continued in the high land either side in a broad shallow synclinal—the high land synclinals and the anticlinal valley between covering a breadth from east to west of ten miles. (*a*) In the synclinal to the *west* (between the Konkaput valley and Great Barrington), the schist has first a dip northwestward of 8° to 25°, but, after three-fourths of a mile, the dip is eastward 20° to 25°, and finally 40° to 50°, just east of Great Barrington. (*b*) In that to the *east*, the dip is 5° to 25° to the northeastward, over the high land and mountainous region all the way east from Devany's bluff to the village of Monterey; but on the northeastern side of this high land, at the village of Tyringham, and at South Lee, it is to the southwestward. A section between Monterey and Tyringham, east of north in course, shows the change of dip. The limestone about Monterey dips 25° to the northwest; along the highest part of the road, the gneiss and mica schist of the hills outcrop and have the same dip and strike; descending to Tyringham, five miles to the north, the dip diminishes, and for the last mile is reversed, being to the southwestward; finally, at Tyringham, the limestone comes into view again overlaid by the same kinds of gneiss and mica schist, with a dip of 15° to 25°.

Thus, both *east* and *west* of the Konkaput anticlinal there is as gentle a synclinal; and hence the idea of an overturn cannot be reasonably entertained. It appears to be a general rule, for the eastern or quartzyte part of the limestone area as well as the western, that *the valleys are eroded anticlinals*, and *the ridges* *or areas of high land are synclinals*, a rule exemplified extensively in the continuation of the Appalachians from Pennsylvania to Alabama, where the facts are little obscured by metamorphism. The position of the limestone *beneath* the quartzyte and schists along the Koukaput is then the original position.

This underlying of the thick quartzyte and schists by limestone appears to be a fact in many other parts of the Berkshire region, as in Monument Mountain, in quartzyte ridges east of Tom Ball, and elsewhere, though these examples are not as free as the above mentioned from other supposable explanations. The evidence is complete with or without them, that *the quartzyte and the associated schists in some prominent cases in Berkshire, if not all*, overlies limestone. In such cases, accordingly, the limestone is the older formation of the two; and this is as true for Vermont as for Berkshire. And where so in either State the quartzyte and the associated schists constitute *synclinals or monoclinals—not anticlinals.*

There is another argument favoring the view that the quartzyte is in *synclinals.* It may be questioned whether lofty anticlinals of quartzyte are a possibility. The quartzyte was originally a deposit of sand, or a sandstone, of great thickness. Now such a sand-bed or sandstone, raised into a close and lofty anticlinal flexure so as to have, as in Vermont, and in some parts of Berkshire, a dip of 40° or 50°, would be sure to have been very profoundly broken by the strain; and thus broken, it would have been exposed to erosion and destruction, and even to removal so as to leave a valley in its place, as has been the usual fact in the Appalachians; while, if bent up into a synclinal, whether shallow or deep, the pressure would tend to promote compactness, consolidation, and preservation. Hence the existence of the quartzyte formation in lofty ridges is strongly against its being in anticlinals.

If then the quartzyte ridges are not anticlinals, *the limestone is the inferior stratum.*

Again: if the quartzyte is Primordial, the underlying limestone is inferior Primordial. Consequently, the quartzyte formation should be elsewhere found separating this inferior Primordial limestone from the limestones of the Calciferous, Quebec, Chazy and Trenton periods. But the fact is that this limestone which underlies the quartzyte is in many places in Vermont continuous with the rest of the limestone formation, one area of limestone stretching from the quartzyte quite to the Taconic slate-belt where are Trenton and Chazy fossils in it. We naturally inquire—how under these circumstances can it be that the quartzyte formation belongs any where between the Trenton and that inferior limestone? Is it not necessarily superior to all the continuous Lower Silurian limestone formation? But if thus superior, the quartzyte is not Primordial; it is not the equivalent of the Red Sandrock; it is even related in age to the Taconic slates; these overlying a western portion of the limestone and the quartzyte formation an eastern. If so, *the eastern quartzyte formation is of the age of the later Trenton, or the Cincinnati group, both in Vermont, Berkshire and Connecticut.*

It will be remembered that the axis of the iron-ore belt is situated in the vicinity of the quartzyte in Vermont, but in the vicinity of the Taconic range in Berkshire; and even west of the Taconic range for the region south of the latitude of middle Berkshire (this vol., p. 133). Thus the quartzyte and the Taconic slates have the same geological relation to the iron ore belt; and this again suggests the idea that the two are of the same age—both of the Cincinnati or Hudson River group if one is.

These remarks make apparent the difficulties and doubts surrounding the question as to the age of the quartzyte, doubts which only new discoveries of fossils can wholly set aside.

The collections of Yale College contain specimens of the "Modiolopsis" and "Orthoceras" reported by the Vermont Report as occurring in the Quartzyte, which were received by me from the late Professor Adams, many years since, when he had charge of the earlier uncompleted survey of that State. There is but one specimen of each—not enough for a decided opinion about them. Quite recently I have seen other specimens in the Amherst College Museum. One is a piece of quartzyte with many casts of one valve of the so-called "Modiolopsis;" and another contains several of the "Orthoceras;" and I have found that both are unquestionable fossils. The former is the shell of a small lamellibranch about six and a half lines long and five broad. The so-called *Orthoceras* is a slender conical tube filled with quartzyte; and it was apparently without septa —no remains of them being present within; the specimen in the Yale collections has a length of 0·6 in.: a diameter, at the larger (broken) end, of 0·24 in., and, within a twentieth of an inch of the smaller rounded end, of just half this. It appears to be a *Theca*-like species. The lamellibranch seems to indicate, as Professor James Hall concluded, that the quartzyte is not Primordial, and that it must be later in age.

The facts that have been reviewed have established: (1) The Lower Silurian age of the limestone series as a whole; (2) the unity of position, and of epoch of uplift, of the series; (3) the very probable Trenton and Chazy age of the limestone adjoining the whole of the Taconic slate-belt or range; (4) the equally probable Upper Trenton or Cincinnati age of the Taconic rocks. But the age of the more eastern portion of the limestone and of the quartzyte and schists remains undetermined. My opinion is that the quartzyte will be found to be newer than the Red Sandrock, and of the same age essentially as the Taconic slates.

[To be continued.]

ART. XXIX.—*On the preparation of Cylinders of Zirconia for the Oxy-hydrogen Light;* by JOHN CHRISTOPHER DRAPER, M.D., LL.D., Professor of Natural History in the College of the City of New York.

SUCCESS in the use of the microscope for the purpose of projecting magnified representations of microscopic objects on a screen depends primarily upon the light employed, especially when high powers are used, as for example, a quarter inch objective. To answer the purpose in question the light must possess: 1st, intrinsic brilliancy; 2d, the brilliancy must be as nearly as possible invariable; 3d, it must retain its fixity of position in the optical axis of the apparatus.

If the experimenter has a good heliostat, the light from the sun fulfills these conditions better than any artificial light; but, experience teaches the unwelcome lesson that though sunlight is preferable to any other, it scarcely ever happens that it is available at the time it is wanted. The weather is almost certain to be either cloudy or hazy just at the hour when it is desired to make an important demonstration, and the lecturer is obliged to postpone it, thereby lessening its value, and often entirely losing its effect. The selection of the best artificial light therefore becomes a matter of importance to those who desire to secure the advantages to be derived from the successful demonstration of such microscopic objects as preparations of animal and vegetable tissues, animalcules, the circulation of the blood, etc.

The artificial lights possessed of sufficient intrinsic brilliancy are: 1st, the electric arc or light; 2d, the magnesium ribbon light; 3d, the oxy-calcium light; 4th, the oxy-magnesium light; and 5th, the oxy-zirconium light. The first has greater brilliancy than any other in the list, but in addition to fifty or one hundred cups of a nitric acid or bichromate battery a good regulator is also necessary; this involves a very considerable expenditure of money, and even when this is made, the labor and trouble required to manage the battery, and the continued change in the part of the carbon electrodes between which the arc of light passes renders its use unsatisfactory.

The magnesium ribbon light has the great disadvantage of the emission of fumes of oxide, which coat the surface of the condensing lenses in spite of all attempts to dispose of it otherwise. The light also is not concentrated on a small fixed surface; but, is emitted from a varying length of ribbon.

The oxy-calcium light produced by projecting the flame of mixed oxygen and hydrogen gases upon a cylinder or pencil of calcium oxide is the one generally employed. It is fixed in its position in the optical axis of the apparatus, it is thrown into operation with comparative facility when cylinders containing the compressed gases are available, and it has sufficient intrinsic brilliancy for the majority of experiments. The difficulties in the way of its use are however serious, and it is very desirable that they should be lessened. They arise chiefly from the volatility of the calcium oxide at the intensely high temperature employed. The volatilized material depositing on the condensing lenses prevents the passage of the luminous rays, and the cavity formed in the cylinder of lime at the spot where the flame impinges soon interferes with the brilliancy of the light; this necessitates a change in the position of the lime cylinder to present a new surface to the action of the flame, and this in its turn implies a distraction of the attention of the experimenter, which interferes seriously with the satisfactory management of his subject. Though the attempt is made to avoid this difficulty by clock work, or other mechanical contrivances, they are still unsatisfactory in their action. Another serious objection is the necessity of placing the cylinders in a closed vessel when not in use to protect them from the action of the air.

The oxy-magnesium light is similar to the preceding, differing only in the substitution of a cylinder or pencil of magnesium oxide for calcium oxide, and the light emitted is of equal brilliancy. Following the instructions given for the preparation of these cylinders, I have taken the greatest pains to procure samples of magnesium oxide of the utmost purity. I have also tried various methods for its preparation, among which the combustion of the metal in oxygen may be mentioned, but failure has thus far attended all efforts to make pencils or cylinders which could withstand the intense heat of the flame of the mixed oxygen and hydrogen gases without undergoing volatilization. The pencils obtained were fully equal in this respect to those of calcium oxide; but, I did not find any superiority that repaid the trouble of their preparation.

The oxy-zirconium light produced by the action of the flame of mixed oxygen and hydrogen gases on a cylinder of zirconium oxide meets all the requirements of the case in question. It has the intrinsic brilliancy, the invariable brilliancy, the fixity of position in the optical axis of the apparatus, and it does not volatilize under the heat employed. The condensing lenses remain free from deposit, and after the light is once adjusted the experimenter can carry on his demonstrations without the distraction of his attention that attends the use of the other lights. All that is necessary is according to the size of the reservoirs of compressed gas to open the cocks a little as the pressure diminishes. There is also no necessity to remove the zirconium oxide pencil from its position, as is the case with the calcium oxide, it may on the contrary remain *in situ* for any length of time, and the apparatus is always ready for use whenever it is wanted.

Though the standard works on chemistry generally mention the light-emitting power of zirconium oxide under a high temperature, the only successful attempt that has been made to apply it practically that I am aware of was that of Tessié du Motay. Unsatisfactory references to his process for preparing zirconia cylinders are to be found in various chemical works and journals, the best that I have seen being that given on page 47 of "Crooke's Select Methods in Chemical Analysis." The careful reader of this and other articles on zirconia will be prepared to expect difficulties in the way of its preparation, and it is to the removal or lessening of these difficulties that I now propose to address myself by the minute relation of the process I have finally adopted after many weeks of experiment.

The subject naturally divides itself: 1st, into the preparation of zirconium oxide; and, 2d, the preparation of the cylinders or pencils.

Preparation of zirconium oxide.

The compound of zirconium used is that known as the zircon of North Carolina. It is essentially zirconium silicate, and the composition of this and other specimens of zircon will be found in Dana's Mineralogy. The difficulty in the operation consists in the complete removal of the silica and of the sodium compounds used in the disintegration of the mineral.

1st. Select the zircon crystals or fragments thereof of as light a color as possible, and carefully remove all attached foreign matter; provide about ten grams in weight.

2d. Reduce five or six grams to powder in a steel mortar; or, by first heating to bright redness and chilling in water while very hot the same may be done in a porcelain mortar. Remove any mica or other foreign matter that may appear.

3d. Complete the pulverization in an agate mortar, introducing small quantities at a time, and reduce to an impalpable powder. The final yield of zirconia depends on the thoroughness with which this is done.

4th. Weigh out two grams of the fine zircon powder and mix it intimately in a mortar with ten grams of dry sodium carbonate, place the mixture in a covered platinum crucible of twenty cubic centimeters capacity.

5th. Place the crucible over a strong Bunsen flame; the burner should be at least fifteen millimeters in diameter; in about twenty minutes the mass in the crucible will have shrunken to one-third of its original volume if the heat is sufficient. To secure uniformity in temperature of the crucible

I have employed the following device. The platinum crucible being placed in a triangle of platinum wire supported on the ring of a retort stand, a graphite crucible having a diameter of five centimeters was taken and an opening fifteen to twenty millimeters in diameter made in its bottom. It was then placed mouth downward over the platinum crucible, with its mouth at the level of the bottom of the latter, and resting on the same support. A brass or iron tube two and a half centimeters in diameter and six to eight decimeters in length was placed vertically over the bottom of the graphite crucible, resting on it and enclosing the opening previously made therein. A furnace was thus constructed, the long tube being the chimney, giving a good draught, and the graphite crucible the body which confined the flame to the surface of the enclosed platinum crucible and heated it equally.

6th. The shrinkage of the mass having been satisfactorily accomplished it is to be fused; for this purpose a powerful gas blowpipe flame urged by a foot bellows answers very well. In place of the ordinary blowpipe flame I have used a modification contrived by my assistant, Mr. Ivin Sickels. It consists of a large Bunsen burner two centimeters in diameter, the upper opening is closed by a cap through which seven small tubes pass, each having a diameter of two and a half millimeters. The lower openings of the burners are also closed except one through which a tube passes and communicates with a foot bellows. Coal gas being turned into the burner, ignited, and the bellows thrown into action, seven clean sharp pointed blowpipe flames are produced which give a very intense heat.

The mass in the platinum crucible having been fused and the fusion continued until it begins to assume a pasty state, it is again liquified according to the plan of Berzelius by the addition of caustic soda about equal in weight to that of zircon. The heat being again applied the disintegration of the silicate continues, and if necessary a second addition of caustic soda may be made.

7th. The contents of the platinum crucible having cooled, separate them therefrom, and place in a beaker, add two hundred cubic centimeters of distilled water; any portions of the fused material that adhere to the walls or cover of the crucible are also to be removed by a jet of distilled water and added to the contents of the beaker. An occasional stirring will promote the disintegration of the mass, which is completed in the course of a couple of hours, silicate of sodium, the excess of sodium carbonate and soda dissolving, and leaving a white powder, which according to Dr. Melliss is composed of zirconium oxide, silicium anhydride, and sodium oxide, together with any zircon that may have escaped disintegration.

The contents of the beaker are thoroughly stirred and set aside for twenty-four hours to settle. The clear supernatant fluid is decanted, another two hundred cubic centimeters of distilled water added, the mixture stirred and set aside for twenty-four hours or longer, and when the precipitate has settled the liquid is decanted and the beaker with its contents set on the water bath to dry.

8th. Pulverize the dried material in the beaker with a glass rod, add twenty cubic centimeters of pure hydrochloric acid (Merck's), cover the beaker with a large watch glass and set on the water bath; when the acid has dissolved as much as it will take up, it is to be decanted while hot into a shallow evaporating dish of about five hundred cubic centimeters capacity. A second dose of twenty cubic centimeters of hydrochloric acid is added to the contents of the beaker, and when all lumps are broken down the mixture is transferred to the evaporating dish, a little hydrochloric acid being used to complete the transference.

9th. For the final separation of the silica the contents of the dish are evaporated to dryness on the water bath, and the heat continued until they cease to emit acid fumes, a little distilled water is then added and thoroughly incorporated with the residue by stirring. The mixture is again evaporated to dryness at 212° F. The second drying being completed, about two hundred cubic centimeters of distilled water are added, and when all the soluble material is taken up the mixture is transferred to a filter. On the filter there remains silica and undecomposed zircon. In the filtrate there are zirconium chloride, sodium chloride and iron chloride.

10th. The next step is the separation of the zirconium chloride from the iron chloride, and as completely as possible from the sodium chloride. This I have accomplished as follows. The filtrate being made up to five hundred cubic centimeters with distilled water, washed sulphurous acid gas is passed through the fluid as long as a precipitate forms, or until the contents of the flask smell strongly of sulphurous acid. The mixture is then boiled as long as it emits any odor of sulphurous acid, the loss of liquid being made up from time to time by the addition of distilled water. The precipitate of zirconium sulphite is allowed to settle for a day or two and is then collected on a filter, where it must drain for a day, the funnel being covered with a sheet of paper. As it is impossible to wash the precipitate properly on the filter, it must be carefully transferred therefrom to a beaker while it is still moist by means of a glass rod and jet of distilled water from a washing bottle. The lumps being completely broken up the contents of the beaker are again made up to five hundred cubic centimeters with distilled water well stirred, and when the precipitate has settled it is collected on a filter as before and allowed to drain as long as it will yield any fluid.

11th. The precipitate obtained above is dissolved in as little pure hydrochloric acid as possible, the solution diluted with distilled water to five hundred cubic centimeters and heated to boiling for some time. Ammonia is added to the hot solution, when the zirconium oxide is thrown down and is to be collected on a filter, washed with hot water and allowed to dry at the temperature of the air, the yellowish or whitish lumps resulting are pulverized in an agate mortar, when a white powder is obtained. The quantities I have given in the various operations detailed above apply to two grams of the powdered zircon. For the preparation of a zirconia cylinder of sufficient size the product obtained from four grams of zircon is required, the quantities may be doubled throughout; but, it is better to make two fusions of two grams each and double the quantities given in the latter part of the description.

I have also tried the separation of zirconium chloride from iron chloride by hydrochloric acid; but, though I worked at a temperature of 32° F., the yield was very small and therefore unsatisfactory. In the process by hyposulphite of soda I found it very difficult to get rid of the soda. The process of disintegrating the zircon by chlorine at a high temperature also failed to give satisfactory results in my hands, and I find that Dr. Melliss records the same experience.

Preparation of the Cylinders.

The zirconium oxide powder obtained in the manner described above is to be heated in a platinum crucible and kept at a bright red for five or six hours; it will under these circumstances shrink considerably in volume. I have sometimes in addition submitted the powder to the heat of the oxy-hydrogen flame with advantage, spreading it out for this purpose on a piece of platinum foil supported on a slab of iron, and directing the flame on the powder. The operator should wear smoked spectacles. The powdered oxide thus condensed by heat is then moistened with just enough water to give it a tendency to form small lumps. In this condition it is placed in a cylindrical mould and submitted to severe pressure by a piston fitting closely to the cavity of the cylinder, both of which should be properly oiled. The size of the pencils I have prepared is about six millimeters in diameter and one centimeter in length. When in use they are mounted so as to present one end to the action of the oxy-hydrogen flame, when a brilliant circular spot of light is formed admirably adapted for all kinds of optical experiments.

The cylinder in which the pencils have been compressed is about two centimeters in diameter and four centimeters in length; the cavity running centrally through it is six millimeters in diameter, the piston rod fits closely, and both it and the cylinder are of hardened steel; the source of compression is a small hydraulic press, and the pressure employed is about two tons. The pencil is forced from the cylinder after compression by the press itself, and is very hard. It is allowed to dry slowly and is then ready for use. When first heated the temperature is gradually increased until at last the full force of the oxy-hydrogen jet is employed. In case the pencil chips or loses any part of its substance the portions are to be preserved and ground up with old pencils in an agate mortar mingled with a little fresh zirconia powder and compressed in the cylinder. The pencils thus obtained from portions of older ones are generally superior to those made entirely from fresh oxide.

In the process of Tessié du Motay certain agglutinant materials are employed in preparing the pencils; but these reduce the brilliancy of the light considerably. With care in the management of the pencils the use of agglutinants may be avoided, and though they may be necessary in the case of pencils to be handled by an ordinary peripatetic calcium light manipulator they are not only unnecessary in the hands of a lecturer; but, are also detrimental exactly in the proportion in which they reduce the brilliancy of the light.

If the zirconium oxide is free from silica there is no evidence of fusion on the extremity of the pencil, though it may have been submitted to the action of the flame for a full hour. If on the contrary silica is present the spot on which the flame impinges becomes glazed, giving evidence of fusion, and the brilliancy of the light decreases greatly. The pencils made from the zirconia prepared in the manner related above have been tested alongside of those made from zirconia prepared by Merck, which is stated to be pure, and is sold at the rate of one dollar per gram. Whatever the process may be that is used in its preparation it does not give a product as free from iron and silica as the one which I have described, nor does it possess the same illuminating power.

June 22d, 1877.

ART. XXX.—*Mineralogical Notes.* No. V. *On the occurrence of Garnets with the Trap of New Haven, Connecticut;* by by EDWARD S. DANA.

GARNETS have been recently discovered in connection with the New Haven trap rocks, at two distinct localities; and their method of occurrence presents some points of considerable interest.

These "trap rocks," as they are commonly called, belong to the system of dikes of igneous rocks which characterize the Mesozoic sandstone areas of the Atlantic border. Mr. G. W. Hawes has given these rocks a thorough chemical examination,* and has shown that they have all essentially the same composition, being for the most part true dolerites, but including also the hydrous, chloritic variety called diabase. I take the liberty of quoting here Mr. Hawes's analysis of the trap from West Rock, which, as he states, is "the typical rock of this region." Specific gravity 3·03.

Silica	51·78
Alumina	14·20
Iron sesquioxide	3·59
Iron protoxide	8·25
Manganese protoxide	0·44
Lime	10·70
Magnesia	7·63
Soda	2·14
Potash	0·39
Phosphorus pentoxide	0·14
Ignition	0·63
	99·89

The writer has made a microscopic examination,† by means of thin sections, of this series of rocks, including, among many others, specimens from West Rock (see the analysis above) and also from the two localities where the garnets have been found, viz: East Rock and Mill Rock. These three points, it should be stated, are within four miles of each other, all lying just outside of the limits of the city of New Haven. It was found that the specimens from the localities named were identical in mineralogical character, and that they were all quite free from any alteration. The mineralogical constituents are as follows: A triclinic feldspar which Mr. Hawes has shown chemically to be labradorite, pyroxene, and magnetite, also more or less chrysolite, and a little apatite in minute acicular crystals.

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* This Journal, III, ix, 185, March, 1875.

† This Journal, III, viii, 390.

Garnets from East Rock.

At the East Rock locality the trap is very distinctly columnar, and the garnets occur on the vertical surfaces of the columns where they have been exposed in the process of quarrying. The spot at which they are found is in the body of the dike, far away from the line of contact with the sandstone; they are scattered here quite freely over a considerable surface; a careful search for them, however, along the extended front of the Rock, failed to reveal any other locality.

The associated minerals are: Magnetite, apatite, pyroxene now altered to chlorite, calcite, and also in traces chalcopyrite and sphalerite.

The garnets themselves are uniformly crystallized in rhombic dodecahedrons, with the edges truncated by the planes 2–2. Isolated crystals, however, are rare; more commonly they are grouped together in nearly parallel positions in very pretty little rosettes. These groups are scattered over the exposed surface of the rock, and are quite characteristic of the locality. Still, again, the crystals are crowded together, without any regularity of position, into crusts of some little thickness.

The color of the garnets is generally dark-brown to jet-black, though occasionally they are yellowish-brown. Their luster is very brilliant, and in general they are entirely free from alteration. An analysis of the garnets proved, what indeed was suggested by their appearance, that they belonged to the variety *melanite*, or a calcium-iron garnet having the formula $Ca_3FeSi_3O_{12}$. The material analyzed was taken from the crystalline crusts which have been mentioned. It was selected with care to ensure freedom from the rock, and still more from the apatite crystals, which, as remarked below, were intimately associated with the garnet. The specific gravity was 3·740.

The mean of two analyses gave:

Silica	35·09
Iron sesquioxide (with AlO_3 *trace*)	29·15
Iron protoxide	2·49
Manganese protoxide	0·36
Lime	32·80
Magnesia	0·24
Ignition	0·35
	100·48

It has been recently shown by Knop* that the melanite crystals from several localities in the Kaiserstuhlgebirge and also from Frascati contain from three to seven per cent of titanic acid. In view of this fact special tests were made for titanic acid in the progress of the analysis; they served, however, only to prove its absence. The magnetite was also tested qualitatively for titanic acid, but none was discovered.

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* A. Knop, Zeitschrift für Krystallographie, i, 58, 1877.

The associated minerals deserve also a few words of description. The *magnetite* stands first in order of abundance. It appears in the form of brilliant octahedrons, scattered sometimes thickly, sometimes sparsely, over the surface of the rock; it uniformly underlies the garnet where they occur together. The octahedrons of magnetite are sometimes unmodified, but generally the solid angles are replaced with the planes of the form 3-3, and the edges beveled with those of the form 2-2; an *m-n* form is also common, but with planes so rounded as not to admit of determination. The development of the last form occasionally produces irregular bullet-shaped crystals. The octahedral faces are brilliant, the others dull.

The *pyroxene* occurs in minute dark-green crystals, destitute of luster; they are crowded together on the surface of the rock. These crystals are strictly pseudomorphs after pyroxene, for though having unquestionably its form, they are so soft as to be easily cut with a knife, and in the powder have all the appearance of chlorite.

The *apatite* occurs in very minute prismatic crystals of a yellowish-green color. They are most common on and among the crystals of pyroxene. They are more numerous, however, than would appear at first glance, since a careful examination shows that they interpenetrate the garnet crystals in great numbers. The crusts of garnet particularly, which are apparently perfectly homogeneous, are found when broken up to be penetrated in every direction with these minute apatite needles. In this respect the garnets resemble those of the Kaiserstuhl described by Knop.

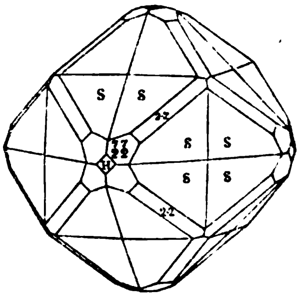
Finally, the *calcite* is found in crusts, and in rhombohedral crystals, covering the other minerals and also the surface of the rock itself. This calcite is very common not only at the point to which the garnets and their associates are confined, but also at many other places, so that it may not have any essential paragenetic relation to them.

All the above minerals are here true secondary products deposited on the columnar surface of the trap, and probably in the following order: magnetite, pyroxene, apatite, garnet, calcite. It will be noticed too, that, of the species which have been mentioned, the magnetite, pyroxene and apatite, are all original constituents of the rock itself, so that it can hardly be questioned that it has furnished immediately the material out of which these later minerals have been formed. The other essential ingredient of the rock, the triclinic feldspar, must have furnished the lime to the garnet and probably to the calcite; the excess of silica above that needed by the garnet, and also the alkalies have disappeared entirely.

Garnets from Mill Rock.

The other garnet locality is at the west end of Mill Rock. In appearance and in method of occurrence the garnets here found are a decided contrast to those that have been just described. They occur on the line of contact between the trap and the adjoining sandstone, and probably owe their origin to the metamorphic action of the heat of the erupted rock. They are found best in seams and little cavities in the trap, where they are implanted as isolated crystals upon an earlier deposit of quartz crystals. Occasional garnets of indistinct crystalline form but presumably of similar origin occur on the surfaces of the sandstone adjoining; scales of hematite produced by metamorphic action are common on the same surfaces.

The garnets in the trap only are distinctly crystallized; the crystals are highly complex and interesting. They appear at first sight to be dodecahedrons, but further examination shows that each dodecahedral plane is replaced by the four planes of a very obtuse hexoctahedron, having the symbol 64 $\frac{64}{63}$; the other forms occurring with this are: 2-2, $\frac{7}{2}$-$\frac{7}{2}$, and *H*. The adjoining figure shows the habit of the crystals. The following angles were measured to determine these forms.



For $\frac{7}{2}$-$\frac{7}{2}\wedge\frac{7}{2}$-$\frac{7}{2}$ (over *H*) =136° 15′, required 135° 59′ 48″.
" " " adjacent (edge B)=149°16′, required 149° 16′ 38″.

For 64-$\frac{64}{63}$ edge B =178° 15′, required 178° 5′.
" " " C =178° 56′, " 179° 6′.

Of the above enumerated forms, the basal plane (*H*) is quite rare with this species, the tetragonal tris-octahedron $\frac{7}{2}$-$\frac{7}{2}$ is new, though it has been observed on fluorite, and also by Klein (as a hemihedral form) on sphalerite; and the hexoctahedron 64-$\frac{64}{63}$ has been observed only on the *topazolite* from Piedmont (Quenstedt), though the related form *i*-$\frac{64}{63}$ was found by Websky on the transparent garnets of Jordansmühl, Silesia.

The Mill Rock garnets have a wine-yellow color, and a brilliant luster. The material available was much too scanty to admit of any chemical examination, but in view of their similarity of form and color, they may safely be referred to the variety *topazolite*.

In addition to the crystallized quartz upon which the garnets are implanted, the only other associated mineral is one occurring very sparingly in silky hair-like fibres. It was impossible to obtain enough for even a blowpipe examination, so that its character remains undetermined.

ART. XXXI.—*A description of the Rochester, Warrenton, and Cynthiana Meteoric Stones, which fell respectively December* 21st, 1876, *January 3d*, 1877, *and January 23d*, 1877, *with some remarks on the previous falls of Meteorites in the same regions;* by J. LAWRENCE SMITH, Louisville, Kentucky.

A SHORT notice of the three meteorites which form the subject of this communication, was published by me shortly after their fall, the detailed account of their flight and fall having been deferred until I could make a more thorough examination. This I am now able to do, as there have been sent to me the entire stone that fell near Cynthiana, and a large portion of the fragments which have been saved of the other two.

The points of interest in connection with these three meteorites are as follows: *First*, they fell within a period of thirty-two days, and within a circumscribed territory of about two degrees of latitude and six degrees of longitude. *Secondly*, they differ from each other in their structural characteristics, and each has some peculiarity distinguishing it from the ordinary type of meteoric stones. *Thirdly*, they fell within a belt of territory, which I shall show has been the lodging ground of all the meteoric masses that have been observed to fall and have been collected in the United States during the past eighteen years, with the exception of about one kilogram.

1. *Rochester* (*Indiana*) *Meteorite.*

The passage of this meteorite through the earth's atmosphere has left but a small souvenir of its visit. It was well observed at Bloomington, Indiana, lat. 39° 12′, long. 36° 32′, by the distinguished astronomer Professor Kirkwood, who communicated to me at the time his observations; and he has subsequently given them more in detail to the American Philosophical Society, with the observations he had collected from others. I will therefore simply give a summary of the phenomena attendant upon its flight before describing the chemical and mineralogical characteristics of the stone which fell.

The bolide made its appearance about nine o'clock P. M., December 21, 1876, and was of extraordinary magnificence. It passed eastward over the States of Kansas, Missouri, Illinois, Indiana, Ohio, and parts of Pennsylvania and New York. Although no observations were made in the two last mentioned States, still Professor Kirkwood is doubtless correct in defining this as its course. At Bloomington its elevation was fifteen degrees. According to the calculation, the length of its observed track was from 1,000 to 1,100 miles, one of the longest on record. Its height is supposed to have been thirty-eight miles above the place where the small fragment fell from it.

In various parts of its track, it threw off fragments, accompanied with the usual rumbling noise and commotion in the atmosphere common to the flight of these bodies. When crossing Indiana, the main body was followed by a train of smaller bolides, many of them of the apparent size of Venus or Jupiter. Its velocity in reference to the earth's surface appeared to be from eight to twelve miles per second. The pyrotechnic display is said to have been transcendently beautiful, hardly equalled or surpassed by any previous occurrence of the kind. The cause of this brilliancy lay in the physical structure of the body, which will be detailed farther on.

The fragment which fell.—The only fragment of this bolide known to have fallen was one found on the farm of Mr. Morris, three miles northwest of Rochester, Indiana, lat. 41°, long. 86°. This farmer heard the explosion, and shortly afterward noticed a body strike the ground not far from him. There were six inches of snow upon the ground, and, on the following morning he found the stone, which had rebounded to a short distance from the place where it first fell, it not having penetrated the ground. The entire stone did not weigh four hundred grams, and as we have not heard of the fall of any other mass, it is reasonable to suppose that it was dissipated into very minute fragments and dust, as in the case of the Hessle stones and other similar falls.

The manner in which the molten matter of the exterior of many of these meteorites is swept over their surfaces, in shining streaks, covering freshly broken surfaces, show clearly that this disintegration is constantly and rapidly going on in these bodies during their passage through the air. I have in my collection many fine examples illustrating this fact.

Professor Kirkwood is of the opinion that this bolide never passed out of our atmosphere, which is in accord with my general view on this subject, viz: that a bolide rarely, if ever, gets entangled in our atmosphere without being entirely reduced to fragments or powder.

The stone has been broken up into many small fragments, of which I have fortunately secured a good portion. Others have been lost and a few have found their way into collections. With the exception of the largest specimen in my collection, weighing ninety-five grams, hardly any other fragment weighs over thirty grams. It is important to treasure these specimens, small as they are, for it is a remarkable stone of its type. It is of the pisolitic variety, very friable, of a gray color, easily crushed under the fingers into light powder (some of it to fine dust), and to small globules, some of them *perfectly spherical*, of which I have specimens two millimeters in diameter. It resembles more closely the Aussun stone than any other I know of, although much more friable. This peculiar structure, so often seen in many parts of meteoric stones, has recently attracted much attention, Professor Tschermak, of Vienna, having recently published an interesting paper on the subject.*

The specific gravity of the stone, taken with several average specimens, is 3·55. There is nothing peculiar about the coating on the specimens I have examined; it is of a dull black and quite rough.

Chemical examination.—The stony part of the meteorite separated almost perfectly from the metallic part still contained a notable portion of troilite that could not be separated mechanically. The amount of sulphur found in that part of the meteorite indicated the amount of troilite present, viz: 3·31.

The stony material, when treated with chlorhydric acid over a water bath, affords soluble part 47·80 per cent, insoluble 52·20 per cent, and is constituted as follows:

	Soluble part, per cent.	Insoluble part, per cent.
Silica	34·55	57·81
Iron protoxide	27·75	11·04
Alumina	trace	·23
Lime	trace	5·31
Magnesia	36·38	24·97
Chromium oxide		·10
Soda	·46	·84
	99·14	100·30

I separated some of the globules perfectly free from the intervening matrix, which is easily done by rubbing a piece of the stone between the fingers. Very minute specks of iron could be distinguished on them, and when pulverized and treated with chlorhydric acid, they gave about the same result as the matrix, viz: soluble, 46·80 per cent; insoluble, 53·20 per cent; and the magnesia in the soluble part was 34·48 per cent, showing clearly that they were merely concretions of the matrix of the stone.

The nickeliferous iron, which was separated mechanically, is composed of:

Iron	94·49
Nickel	4·12
Cobalt	·51
	99·12

The quantity of iron was too small for an examination of the other constituents, as phosphorus and copper, but they were no doubt both present.

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* **Sitzungsb. Akademie der Wissenschaften, vol. lxxi, p. 661.—Wien.**

Mineral constituents of the Stone.—Careful examination under the microscope of the broken surface, as well as of a section rubbed down very thin, show the stone to be composed of the unisilicates and bisilicates usually found in these bodies, mixed with nickeliferous iron and troilite; nothing like anorthite is distinguishable. The first two minerals constitute the bulk of the stone, and there is possibly more than one variety of each of these minerals present. The nickeliferous iron is quite abundant, although Professor Shepard states that from a casual observation he estimates it at one per cent; by the careful method adopted for separating it, I find in two average specimens over ten per cent. The particles of iron are very bright and lustrous, looking as if they were covered with plumbago, although there is no evidence of the presence of the latter mineral. The troilite is not detected so readily by the eye as it is by chlorhydric acid. One of the spherules was rubbed down to a thin section and examined by polarized light; and in this way it was found to contain both classes of silicates referred to, a fact, as already stated, sustained by chemical examination. I consider the mineral constituents of the Rochester stone to be about as follows:

Bronzite and pyroxene minerals	46·00
Olivine minerals	41·00
Nickeliferous iron	10·00
Troilite	3·00
Chrome iron	·15

2. *Warrenton (Missouri) Meteorite.*

About sunrise, on the 3d of January, 1877, five miles from Warrenton in the State of Missouri, lat. 38° 50′, long. 91° 10′, a sound was heard by certain observers similar to the whistle of a distant locomotive; or, as stated by others, like the passage of a cannon ball through the air. The sound came from the northwest, and became louder and louder to four observers near Warrenton. On looking up they saw an object falling, which struck a tree, breaking off the limbs, and then coming to the ground with a crash. The observers were fifty or sixty meters distant from the spot where it fell. On approaching the place they saw a mass of stone broken into a number of pieces. From the fragments they suppose it to have been originally of a conical form, and about eighteen inches in length. The snow was melted, and the frozen ground thawed near where it fell, but the pieces, although warm, were easily handled. The weight was estimated to have been about one hundred pounds; but, whether this estimate be correct or not, only about ten or fifteen pounds of fragments have been preserved, a good portion of which is in my possession, mostly in small fragments;

some specimens are in the cabinet of Yale College, and others scattered about among the inhabitants of the country where it fell.

As regards its temperature at the time of falling I would say that I have a specimen, which gives as it were a satisfactory record that it was not very hot when it struck the tree, for a portion of the fibers of one of the branches is adhering to the surface entangled in the rough crust of the stone, and these delicate fibers show not the slightest signs of having been heated. A fact to be noted in connection with the fall of this meteorite is that no explosion was heard, or any luminous phenomena produced, by its passage through the air after it was first noticed; this may be in part due to the fact that the fall happened at sunrise; but it was no doubt a meteorite well spent in its rapid motion through the atmosphere, and dropped quietly like an exhausted bird in its flight. Its direction, so far as made out, was from northwest to southeast.

Aspect of the Stone.—Studied by the various fragments that are under my observation, it differs in a marked degree, although pisolitic, from the one just described, and which fell only a few days previously. It has its own points of peculiar interest, and is not like any meteorite that I am familiar with, except the Ornans meteorite, which fell July 11th, 1868; and this it resembles closely in every particular, as may be seen by comparing my results with those of Pisani (Comptes Rendus Acad. Sci., 1868, vol. ii, p. 663), although his method of recording the analytical results is different from mine, and the specific gravity, as made out by him, is higher than mine, which is not singular in different specimens of these porous bodies. Its crust is dull black, and quite thick; in many places, of several centimeters square, from two and one half to three and one half millimeters thick (the thickest I have ever seen), where the crust is a rough scoria that sometimes terminates abruptly on a smooth portion of the crust, and is doubtless produced by the melted matter on the surface being forced backward and opposite to the direction of the flight of the stone, being swept off one portion of the surface, and leaving this part smooth, and piled up behind it, in the form of a surface of scoria.

The interior of the stone has a very dark uniform ash color, and is soft and easily crushed; the latter fact accounts for its having broken into fragments as it struck the ground. Its specific gravity is 3·47, and the amount of metallic matter contained in it is small.

Chemical composition.—The stone pulverized and freed from metallic particles gave on analysis an amount of sulphur equal to 3·51 per cent of troilite; the amount of nickeliferous iron was small, being equal to 2·01 per cent. The stony minerals treated with chlorhydric acid gave—

Soluble in acid	80·40	per cent.
Insoluble in acid	19·60	per cent.

composed as follows:

	Soluble.	Insoluble.
Silica	33·02	56·90
Iron protoxide	37·57	10·20
Alumina	0·12	·20
Lime	trace	7·62
Magnesia	28·41	22·41
Soda	·07	1·00
Nickel oxide	1·54	
Cobalt oxide	·31	
Chromium oxide		·33
	101·04	97·66

I obtained chrome oxide thirty-three per cent, indicating 0·50 of chrome iron, if the chrome be present in that form. There is no way, however, by which I can decide this question, although it is probable, since the chrome is in the insoluble part; the oxide of nickel, with the exception of perhaps a minute portion, belongs to the composition of the soluble silicates.

The nickeliferous iron contained in this stone is very small in quantity. This on analysis gave

Iron	88·51
Nickel	10·21
Cobalt	·60
	99·32

Mineral constituents of the Warrenton Meteorite.—A microscopic examination did not give me any clear indications, for it is not possible to prepare a good section for observation. Its chemical examination, however, shows the usual uni- and bi-silicates, of the olivine and bronzite and pyroxenic types. The most marked feature is the preponderance of the olivine minerals, constituting four-fifths of the mass. The proportion of the mineral constituents is about as follows:

Olivine minerals	76·00
Bronzite and pyroxenic minerals	18·00
Nickeliferous iron	2·00
Troilite	3·50
Chrome iron	·50

3. *Cynthiana* (*Kentucky*) *Meteorite.*

I have called this the Cynthiana stone, although it fell nine miles from that place, in Harrison county, Cynthiana being the nearest important point to the place where it fell.*

*** I will take occasion just here to correct an error that I have seen in several catalogues, among them those of Vienna, the British Museum, and the Garden of Plants. These catalogues designate the meteoric fall described by me in 1858, as that of Harrison county, Kentucky: it should read Harrison county, *Indiana.***

At four o'clock P. M., on the 23d of January, 1877, a brilliant bolide was seen traversing Monroe county, Indiana, in a south-easterly direction, about thirty-five degrees above the horizon. The same bolide was observed by a number of persons in Decatur county, of the same State, lat. 39° 27′, long. 85° 28′, and it disappeared just as it seemed to touch the earth, apparently not more than a quarter of a mile distant. As will be seen, it fell about sixty miles distant from these places. It seemed to fall almost perpendicularly toward the earth's surface. I cannot learn that it was seen by any one in the State of Ohio, but suppose that it was. In the State of Kentucky it was seen over a considerable territory. The phenomena culminated in the usual noises heard in the heavens accompanying the approach of these bodies, and much consternation was produced among the inhabitants of the surrounding country. Fortunately one of the observers, an intelligent farmer (Mr. Cragmyle), heard a solid body strike the ground; he walked immediately to the spot, and dug the stone from a depth of thirteen inches, to which extent it had penetrated the ground. A few days after its fall and before it had become generally known, Professor Kirkwood wrote me a letter, stating what observations had been made in Indiana, and telling me to look out for a meteoric fall somewhere about the region where the stone did fall. I had, however, made the observations and secured the meteorite, before his letter arrived, but the stone had not yet been forwarded to me.

Character of the Stone.—It is wedge-shaped, with one portion of it very extensively and regularly pitted, while the rest is comparatively smooth. The crust is dull black, and, as it reached me, it was as perfect as when it fell. There was a fresh broken spot of two or three square centimeters, which, to a casual observer, would appear to have been made after the fall; but upon close examination, I saw that it had been made prior to the fall, and before the melted matter of the surface had entirely cooled, for a few small specks of this matter have been sprinkled on this broken surface, to which it firmly adheres, and the molten matter is running over one border of it. This could not have arisen from any fusion of that surface, which is too fresh and unaltered to have been heated to any high degree. The fracture was produced by the same cause that produced the pitting.*

The weight of the stone is six kilograms. It is of the harder brecciated variety, and when broken presents a mottled surface, identical with that of the Parnallee stone, which it resembles also in every other particular, the very pale yellow round spots, sometimes five or six millimeters in diameter, are disseminated through the two alike; and so with the triolite, the globular structure in some parts, and a few specks of a black siliceous mineral; and, by a singular coincidence, the specific gravity of the part I tested is identical with that as made out by Maskelyne, viz: 3·41. Under the microscope it presents the appearance described by the same author.

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* This is clearly and fully set forth by Professor Maskelyne, in the Phil. Mag., for August, 1876.

Chemical examination.—The stony material freed from metallic iron, consisted of—

Matter soluble in chlorhydric acid	56·50
Matter insoluble in chlorhydric acid	43·50

Some of the soluble part was composed of troilite, which I could not separate mechanically, but is deducted in the following analysis:

	Soluble part.	Insoluble part.
Silica	33·65	57·60
Iron protoxide	30·83	11·42
Alumina	·11	·43
Lime	trace	5·70
Magnesia	34·61	23·97
Chromium oxide		·38
Soda		1·24
	99·20	100·74

The portions examined contained nickeliferous iron 5·93 per cent, consisting of:

Iron	90·64
Nickel	8·35
Cobalt	·73
	99·72

Mineral constituents of the Cynthiana Stone.—The minerals in this stone are quite easily distinguished by the eye, but are very much more conspicuous under a moderate magnifying power, especially the round and distinct concretions of a light yellow bronzite. The troilite and metallic specks and filaments are also easily seen.

No attempt was made to separate the stony minerals in sufficient quantity for analysis; quantitative tests were made to distinguish their character. From the chemical examination previously made I deduce the following as about the proportion of the mineral constituents:

Olivine minerals	50·00
Bronzite and pyroxenic minerals	30·00
Nickeliferous iron	6·00
Troilite	5·50
Chrome iron	·52

There were no distinct crystals of minerals visible either to the unaided eye or with a lens.

4. *Remarks on the region where these meteorites fell.*

In the study of the three aerolites just described it is interesting to note the relation of the region where they fell to that of previous falls of recent date.

During a period of less than eighteen years there have been twelve falls of meteoric stones in the United States, of which specimens have been collected. All of these, with one or two exceptions, I have described in detail, and furnished specimens to various cabinets in this country and in Europe.

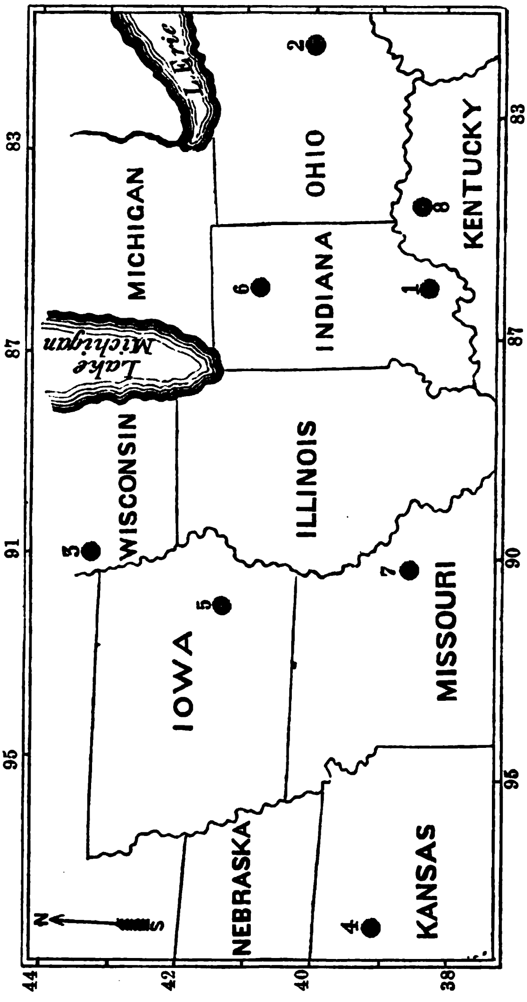
In grouping together these twelve falls and estimating the amount of meteoric matter accompanying them, I have been struck with the singular fact that eight of them, with over one thousand kilograms of matter, have occurred over the prairie regions of the West, not far from my home; and the extreme limits of these falls is within a region not exceeding one-eighth of the surface of the United States, east of the Rocky Mountains. It may be supposed that one reason for this may be that this region is more thickly populated than others, and consequently that there are more observers. This however is not the case, for the population is not much above the average of the country.

I have made a map of the region (see next page) where these eight falls occurred, which shows at a glance their relative positions. The accompanying table gives a few comparative details in relation to each of them.

No.	Time of Fall.	Place of Fall.	Lat.	Long.	Estimated Weight of Fall.
1	28th March, 1859	Harrison Co., Ind.	38° 20′	86° 10′	1· kilo.
2	1st May, 1860	Guernsey Co. (Concord), O.	40	81 30	500· "
3	25th March, 1865	Claywater (Vernon Co.) Wis.	43 30	91	3· "
4	Not known, 1874	Waconda, Kansas,	39 20	98 10	40· "
5	12th Feb., 1875	Iowa Co., Iowa,	41 40	92	500· "
6	21st Dec., 1876	Rochester, Indiana,	41	86	·40 "
7	3d Jan., 1877	Warrenton, Missouri,	38 50	91 10	10· "
8	23d Jan., 1877	Cynthiana, Ky.	38 20	84 20	6· "
				Total,	1060·40 kilos.

There have been four other falls in the United States during the same period; but the aggregate weight of them is less than two kilograms. They occurred respectively, Nov. 28th, 1868, lat. 34° 30′, long. 87°; Dec. 9th, 1868, lat. 34° 30′, long. 87° 50′; Oct. 6th, 1869, lat. 32° 10′, long. 85°; May 21st, 1871, lat. 44° 30′, long. 69° 10′.

Again: in this region more bolides have recently been observed than in any other. Professor Kirkwood has described,



1. Lat. 38° 20′, Long. 86° 10′; 2. Lat. 40°, Long. 81° 30′; 3. Lat. 53° 30′; 4. Lat. 39° 20′, Long. 98° 10′; 5. Lat. 41° 40′, Long. 92°; 6. Lat. 41°, Long. 86°; 7. Lat. 38° 50′, Long. 91° 10′; 8. Lat. 38° 20′, Long. 84° 20′.

as seen by him and others, eight from July, 1876, to February, 1877, the stones from three of them are those described in this paper, the others left no evidence of their passage. By personal observation I have noted, in the last two or three years, three splendid bolides, that were seen to burst in the sky, but of which no fragments were found; these I have described, and still others have been described to me by several observers. It is a still more striking circumstance, that, in the past sixty years, there have been twenty well noted falls of meteoric stones; and of these just one half have fallen within the region mapped by me as including the eight falls of the past eighteen years; and the weight representing them is nearly twelve hundred kilograms—an amount twenty times greater than that of the other ten falls scattered over various regions.

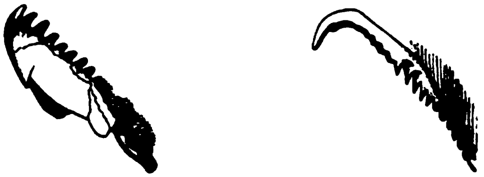
I have mentioned this singular fact not that it has any cosmical significance, but simply as a part of the record I keep of my observations and study of these curious links between heaven and earth. Before very long I hope to put together my more recent speculative studies in regard to these bodies.

ART. XXXII.—*Notice of a new genus of Annelids from the Lower Silurian;* by GEO. BIRD GRINNELL.

THE Museum of Yale College has recently received, from the rocks of the Cincinnati group, a series of fossils which are of unusual interest. The remains are shining black in color, and present a striking contrast to the associated fossils, Trilobites, Brachiopods, Crinoids, etc., which have assumed the color and constitution of the matrix. An examination of these black remains shows that they are the hard chitinous parts of Annelids.

While the presence of animals of this group in the Lower Silurian has been inferred from their "trails" and impressions in the rocks, no portions of their bodies have as yet been found preserved in the deposits of this age. The remains which first suggest themselves for comparison with these specimens are the Conodonts of Pander. Through the kindness of Professor Marsh, the writer has been enabled to examine a number of the original specimens of these fossils, collected by Pander himself near St. Petersburg; and a comparison makes it clear that they are quite unlike the remains referred to. They are widely different in color and form from the material under observation, while chemical tests show that their composition is by no means similar.

These Cincinnati fossils include a large number of specimens, and, as might be expected, there is a wide variation in their form. So little is at present known in regard to the jaws of Annelids, that any general conclusions drawn from the material at the command of the writer would be premature; and for the same reason it would be unwise to distinguish by a name each of the many forms which appear. Further study will doubtless furnish data for a more extended description, with numerous illustrations, which it is hoped will soon be completed.



1. 2.

× 5. × 10.

Nereidavus varians, gen. et sp. nov.

The jaw selected as a type for the genus (fig. 1), is one of the largest and most perfectly preserved of those at hand. It is dark brown, with a coppery luster in some places, this coloring being due to the weathered condition of the specimen. It is hollow at the base and throughout the greater part of its length, and so strikingly resembles the jaw of the common *Nereis pelagica* Linn. of the Atlantic coast, as to render their near affinity almost certain. The denticulations, or teeth, are eight in number, but were probably more numerous originally, since the posterior portion of the specimen is wanting. The anterior tooth, which is the largest, is somewhat twisted outward, not lying in the same plane with its fellows. The length of the specimen is 5·6 mm., the depth beneath the fourth tooth 1·4 mm.

A second very perfect specimen, which may possibly belong with the jaw above referred to, is represented in fig. 2. It contains eighteen teeth, the anterior one quite long and stout, the next five mere slight protuberances, and only to be seen under the microscope, while the remaining teeth are sharp and strong. The length of the exposed portion of this individual is 2·8 mm.; depth under the first of the strong teeth, the seventh in the series, ·22 mm. Since the base of this specimen is buried in the rock and cannot be seen, it is not altogether certain what it is. It bears some resemblance to one of the setæ of *Nereis Dumerilii*, Aud. and M. Ed., figured by Ehlers in his work entitled Die Borstenwürmer, pl. XX, fig. 31.

The specimens under consideration were collected by Professor A. G. Wetherby, near Cincinnati, Ohio. Through the energy and courtesy of this naturalist, a large suite of specimens has been secured and forwarded to New Haven, and to him the writer would express his grateful acknowledgments.

Yale College Museum, New Haven, Conn., July 28th, 1877.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *The Radiometer.*—A large number of papers on this subject have appeared during the past few months. Several of these have been published in Poggendorff's Annalen, and of the rest, excellent abstracts are given in the "Beiblätter" to that journal. They give evidence of a very great amount of ingenuity expended in devising experiments to test the theory of this very remarkable instrument, and they show how easily experimental evidence may be misinterpreted in support of an assumed theory when the phenomena in question are liable to be modified by many adventitious circumstances. Five theories of the radiometer have found prominent and weighty advocates. The first regards the motion of the instrument as a *direct* effect of radiation. The second refers it to electrical action. The third to convection currents. The fourth to the emission of material particles from the vanes or the walls of the instrument. The last finds in the apparatus simply a new heat engine, and sees in the motion a simple result of the difference of temperature of the parts, wholly in accordance with the modern mechanical theory of heat.

When this motion was first discovered it seemed to be a direct mechanical effect of radiation, and there were not wanting ingenious speculations to show how the force exerted by the waves of the luminiferous ether might be resolved so as to produce such an effect. It is to be remarked, however, that Mr. Crookes, to whom we owe the discovery, did not indulge in such speculations, and, as he says, aimed to keep himself unbiased by any theory while he accumulated the facts upon which a satisfactory explanation might be based. But the very name *radiometer* implied, and the whole tenor of his published papers have certainly justified, the common opinion that, until very recently, he regarded the phenomena—he had so admirably developed—as a *direct effect* of radiation, and not, as he now thinks, a secondary result depending on differences of temperature, which may be produced by radiation or by other means. Hence, several experimenters have labored to show that in the motion of the little wheel of the radiometer the reaction was exerted not against anything independent of the instrument, but against the enclosing walls of glass. The early experiments of Mr. Schuster* on this point were very convincing. He hung the whole instrument by a delicate bifilar suspension, and found that while the vanes were revolving under the action of a beam from an oxyhydrogen lamp, the glass bulb also turned slightly in the opposite direction. Soon after M. Salet† constructed a very ingenious apparatus in which this reaction was made to turn a mica disk; and very recently, M.M. Bertin et

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* Philosophical Magazine, Nov., 1876.

† Comptes Rendus, Nov. 20, 1876.

Garbe[*] have published an interesting paper, in which they show by careful measurements that the reaction of the glass bulb fully accounts for the motion of the wheel; and their investigation may be regarded as finally disposing of the radiation theory, by proving that the motion of the wheel of the radiometer is wholly caused by forces which act within the glass bulb.

The electrical theory has never had many supporters. It is, however, defended in two recent articles by J. Delsaulx[†] and W. de Fonvielle.[†] In opposition it is urged that no distribution of statical electricity could maintain a constant motion,[‡] and further, Mr. Crookes[§] cites an experiment of Mr. Cromwell F. Varley, with an apparatus so arranged that the electrical condition could be tested with a delicate electroscope; when not the slightest trace of electrical excitement could be detected, although the motion of the wheel was regularly maintained.

The convection theory has been recently advocated by F. Neesen,[‖] who describes a number of experiments which he thinks indicate that the wheel of the radiometer is moved by the gas currents occasioned by the rising or falling of the residual air particles as they are warmed or cooled, at the surfaces of the vanes or of the enclosing glass walls. But the effects he obtains by placing similar wheels unsymmetrically under the receiver of a mercury pump, do not, as it seems to us, necessitate his explanation, and moreover the distinction between the effect of convection currents and the peculiar motion of the radiometer is strikingly marked in many experiments which have been elsewhere described, the one passing into the other at a certain degree of exhaustion.[¶]

The emission or evaporation theory appears to have originated with Mr. Osborne Reynolds. It was later maintained by Govi,[**] and recently it has formed the subject of an extended article—in three parts—by F. Zöllner.[††] This theory refers the motion to an alternate emission and absorption of material particles—determined by variations of temperature—at the several surfaces, between which the moving forces in the radiometer are exerted. The particles thus emitted may be either those of aëriform substances adhering to or occluded by the solid materials of which the instrument is made—as Reynolds supposed—or it may be, as Zöllner suggests, that these solids themselves *evaporate* slowly into the vaccuous space. Leaving, however, such questions in abeyance—as these physicists prefer,—there is no doubt that the general order of the phenomena might be explained if the assumptions which the emission theory requires could be accepted; but on the other hand, the phenomena which Zöllner adduces in support of his view, may be,—for the most part at least—fully as well explained by the more general mechanical theory of heat. Zöllner endeavors to show* that the mean path of the molecules of the residual gas in the bulb of the radiometer, when it is in the condition of maximum sensitiveness, is not large enough to fulfill the conditions which the mechanical theory requires. On the other side, Crookes† has obtained motion or the reverse, under conditions which certainly appear incompatible with the emission theory. Moreover, the very fact which appears to have been well established by several observers, that, with a certain degree of exhaustion, different for different gases, a point of maximum sensitiveness is reached, and that on further exhaustion the sensitiveness rapidly diminishes, seems to us,—especially when viewed in connection with the experiments just referred to—fatal to the emission theory.

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[*] Annales de Chim. et de Phys., [V] xi, 45, Mai, 1877.

[†] Beiblätter, i, 170. [‡] Beiblätter, i, 329. [§] Pogg. Ann., clx, 143.

[‖] Compare Zöllner, Pogg. Ann., clx, 459. [¶] Proc. Royal Soc., 1874, June 18.

[**] Pogg. Ann., clx, 154, 296 and 459. [††] Comptes Rendus, lxxxiii, 1.

The last theory we have to consider is, as we have said, but a phase of the mechanical theory of heat. The application of the now well known principles of molecular dynamics to the explanation of the new phenomena is said to have been first suggested by Mr. Johnstone Stoney.† Similar views were also very early expressed by Professors Tait and Dewar.‡ More recently they have been adopted by Mr. Crookes,§ and are now very generally accepted by physicists.

According to the mechanical theory of heat, the molecules of any gas which rebound from a surface with a temperature—that is, with a velocity—different from that with which they struck, must cause a recoil, and this must be the general case whenever the temperature of the surface is different from that of the mass of the gas. Unless, however, the density of the gas is exceedingly small, the rebounding molecules almost at once collide with their neighbors, and are immediately driven back against the same surface. Thus the change of temperature merely affects a very thin layer of molecules near the surface, and these are only slowly displaced by convection. In such an atmosphere, the vanes of a radiometer, for example, with the adjacent molecules, are parts of one system, and, by a well known mechanical law, no motion of the system as a whole can be produced by any action between its parts; but when the medium becomes so rare that the mean path of the molecules is comparable with the dimensions of the enclosing vessel, so that some of the molecules, rebounding from the vanes of the radiometer, may even reach the opposite walls, then of course a force is exerted between the opposing surfaces, and the now familiar motion of the wheel is the result. The radiometer is then simply a heat engine in which the action takes place between two surfaces of different temperature, the heater and the cooler of the engine. As such a difference of temperature may be maintained in a great variety of ways, so the apparatus admits of a great number of modifications. Moreover, it is obvious that when, as in most cases, the difference of temperature is the result of radiation, very irregular effects may be produced by the different absorbing or radiating power of the surfaces for the various rays of the spectrum, and also by similar differences in the diathermancy of the glass envelope. It is not surprising then that some of the phenomena which have been met in the course of the numerous investigations already made on this subject, should have been so difficult to trace. There can be no question, however, that the general order of the phenomena is fully explained by this theory. In the postscript just referred to, Mr. Crookes writes, "Twelve months' research, however, has thrown much light upon these actions, and the explanation afforded by the dynamical theory of gases makes, what was a year ago obscure and contradictory, now reasonable and intelligible."

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* Pogg. Ann., clx, 305. † Beiblätter, i, 167 and 330. ‡ Nature, July 15th, 1875.

§ Philosophical Transactions, vol. clxvi, p. 375, in postscript dated June 17, 1877. See also Mr. Stoney's papers. Phil. Mag., V, i, pp. 177-182, 305-314, (1876).

It does, however, still remain to show that the dynamical theory of heat is quantitatively as well as qualitatively confirmed by the new phenomena. The necessary measurements unfortunately present very great experimental difficulties, and the data thus far obtained can only be regarded as rough estimates, and for this reason we do not attach much importance to the criticisms of Zöllner already referred to. Among the results bearing on this question recently obtained, the most interesting are the following.

Of course, according to the theory in question, there would be no motion whatever in an absolute vacuum, and hence, as we have intimated, the molecular pressure on the vanes of a radiometer ought to reach a maximum effect with a certain limited degree of exhaustion. Moreover, as the length of the mean path of a molecule, other things being equal, depends on the molecular weight,—the lightest molecules having the greatest extent of motion under the same conditions,—it also follows that the limit just mentioned should be sooner reached in the residue of a light than in that of a heavier gas. In accordance with these anticipations, Mr. Crookes has found that while with hydrogen the maximum effect is reached at a tension of about 0·0532 millimeters, it is not obtained with oxygen until the tension is reduced to 0·0228 millimeters, or less than one half of the previous value. In an ordinary radiometer, according to the same experimenter, the tension of the residual air is about 0·19 millimeters, but he has succeeded in reducing it to 0·0076 millimeters, and then the velocity of the motion was only one-tenth of the maximum. Still later he states that by heating the bulb to 300° during the exhaustion, he has been able to reduce the tension to one or two millionths of an atmosphere, and that he can most readily secure the condition of greatest sensitiveness by first pushing the exhaustion to the utmost limit of the power of his apparatus,* and then with the aid of a peculiarly constructed cock allowing gas to enter until the proper tension is reached. By using vanes of mica previously rendered anhydrous by ignition and working with hydrogen, he has thus succeeded in constructing a radiometer of such sensibility that it moved under the sole influence of the moon's rays. The results of Finkener on the point of maximum sensibility in different gases confirm those of Crookes, the two series of measurements agreeing as nearly as could be expected, and all these results—with yet others—have been collected in a very interesting paper recently published by M. Bertin.* No one has yet succeeded in pushing the exhaustion so far beyond the point of maximum effect that the radiometer became again insensible to radiation, nor was that to be expected.

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* Crookes has obtained these later results with a new form of the Sprengel pump, contrived by C. H. Gimingham, and an ingenious application of the mercury gauge to measuring low tensions, made by McLeod. Full descriptions of these new forms of apparatus, with figures, will be found in the Beiblätter, i. 175.

It is another consequence of the dynamical theory of gases that a radiometer with a small bulb ought to be more sensitive—under otherwise like conditions—than one with a large bulb, and this also has been fully realized by Mr. Crookes.† Quite recently, Stoney and Moss‡ have published some preliminary results of an investigation, in which they propose to compare the molecular pressure between the "cooler" and "heater" in this new form of heat engine at different distances and with various gas residues, and under varying conditions of tension, temperature, etc. The investigation was begun soon after the publication of Stoney's original communication to the Phil. Mag., March, 1876, and is not yet completed. They give a description of their apparatus, and they call the reaction exerted between the cooler and heater in the radiometer and all similar instruments, "Crookes' Force." We must refer to their paper for details which appear to authorize the conclusion that in a residue of hydrogen having a tension of five millimeters, the molecular pressure, or "Crookes' Force," is sensible at a distance of at least ten millimeters.

Again, although the molecular pressure we are considering must in general conform to the well known laws of hydrostatics, like the tension of the atmosphere, yet the mechanical theory of gases would lead us to anticipate certain striking differences of effect resulting from the great amplitude of the molecular motion in an extremely rarified medium. Thus the tension of the atmosphere does not move the vanes of an anemometer; but a wind does. And in a somewhat similar way—when the wheel of a radiometer is made like that of the anemometer—the resultant of the recoils due to the acceleration of the rebounding molecules will be greater on the convex than on the concave surface of the cups, although being made of thin metal plate, the temperature of the two surfaces must be essentially the same. Such effects have been studied both by Crookes§ and by Zöllner.‖

It is greatly in favor of the view of the subject last presented that it does not invoke a new agency or exaggerate an old one to explain the new phenomena; but it is merely a new phase of an already well established theory, which, by thus readily marshalling the new phenomena, becomes more firmly established. Indeed, to those who accept this theory the radiometer becomes an instrument of the very highest interest, affording as it does, another and very striking manifestation of molecular motion. Moreover, when we shall be able to overcome the experimental difficulties so as to estimate with certainty the force exerted under determinate conditions, we may hope to obtain by its aid a direct measure of absolute molecular magnitudes.

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* Annales de Chimie et Physique, V, x, 396, Mars, 1877. † Beiblätter, i, 165.

‡ Beiblätter, i, 318, No. 6; also Proc. Roy. Soc., xxv, 553.

§ Beiblätter, i, 169. ‖ Pogg. Ann., clx, 159.

We may be permitted to add to this notice a brief account of a few experiments made with the radiometer at Cambridge in the spring of 1876, soon after the instrument had been received from Europe. We became at once greatly interested in the new phenomena, and with the aid of a skillful glass blower made more than a hundred instruments of different patterns. Our experience led us at once and independently to the theory of its action now generally received; but although we sustained this view in our college lectures, in a communication to the American Academy, and in a popular article in the Boston Daily Advertiser, we did not otherwise publish our results, because we felt that the field had been in a measure preëmpted by the discoverer of the phenomena, who was then investigating the subject, and who, we felt sure, must come at last to the same conclusions which we had reached. Our results can now add nothing to the strength of the theory, which has been since so well worked out by Mr. Crookes, but two of the experiments have never been—so far as we know—described before, and being so simple that they can be easily repeated in any physical cabinet, a description of them, even at this late day, may have an interest for teachers of physics.

We first experimented with a common radiometer having mica vanes blackened on one side, which we placed in a beam of parallel rays from an oxyhydrogen lantern; and having satisfied ourselves—by using an alum cell—that the rays acted chiefly at least through their heating and not their luminous power, we made at once this experiment. We placed an opaque screen near the radiometer so that only the blackened faces should be exposed as the wheel turned the vanes into the beam of light. We then counted with a stop watch the number of seconds which passed during ten revolutions. We then in a similar way exposed only the uncoated faces; when the wheel continued to turn in the *same direction*, although much more slowly than before. Again we counted the revolutions. Lastly we counted the revolutions while the beam shone on both sides of the vanes as usual. We repeated the experiment several times, and were surprised at the remarkable constancy of the results. They were as follows:

	Time of ten revolutions.	Revolutions in same time.
With both faces exposed	8″	319
With lampblack faces alone exposed	11″	232
With mica faces alone exposed	29″	88

and it will be noticed that 88+232 equals very nearly 319. Now any uniform force whatever, acting from without and at once on the two arms of a lever like these vanes, must act differentially and not concurrently, as here. Hence the reaction which causes the motion must take place between the parts of the instrument itself; or else we are driven to the most improbable alternative that lampblack and mica should have such a remarkable selective power that the impulses, then supposed in some mysterious way to be imparted by the beam of light, could exert a repulsive force at one surface and an attractive force at the other. Were there, however, such an improbable effect, it must be independent of the thickness of the mica vane; while on the other hand, if, as seemed to us most probable, the whole effect depended on the difference of temperature between the lampblack and the mica, and if the light produced an effect on the mica surface only because the mica plate being diathermous to a very considerable extent, the lampblack became heated through the plate more than the plate itself, then it would follow that if we used a thicker mica plate, which would of course absorb more of the heat, we ought to obtain a marked difference of effect. Accordingly we repeated the experiment with an equally sensitive radiometer—which we made for the purpose with comparatively thick vanes; and with this the effect of a similar beam of light on the mica surface was absolutely null, the wheel revolving in the same time whether these faces were protected or not. It was now an obvious step to heat the glass of the bulb independently of the vanes in order to see if under these circumstances we should not obtain a reverse action. This was easily effected both by warming the glass over a lamp and also by placing the bulb tangentially toward the beam from the lantern, so that it heated the glass without striking the vanes of the wheel. We thus easily obtained the now familiar reverse motion, but which was to us a new discovery. We therefore felt ourselves justified in speaking of the radiometer, as we did in the communications referred to, as a heat engine, of which, when moving in the ordinary way, the lampblack surface of the vanes is the "heater" and the inner surface of the glass bulb the "cooler," but in which these conditions could be reversed as just described. And then the parallel with the steam engine, which we drew, suggested the extension of the dynamical theory of gases to include the new phenomena almost in the very words used above. Moreover, while exhausting the large number of radiometers of which we have spoken, we noticed variations in the effects produced, caused by differences in diathermancy between crown and flint glass, and were thus led to realize what an important part this property of matter played in these phenomena. We also observed that the larger the bulb to the greater degree must the exhaustion be pushed in order to obtain equal sensitiveness. We further found that the same sensitiveness could be more readily obtained with a residue of hydrogen than with one of air, and we recognized plainly that there was with each instrument a point of maximum sensitiveness which could not be exceeded. We had also devised an apparatus for measuring the force exerted under determinate conditions, but our experiments were brought to an end by the sudden death of the only skillful glass blower in our neighborhood.

Soon after these experiments, Mr. B. O. Peirce, now assistant in the Physical Laboratory of Harvard College, made the following striking comparison of the relative effects produced by a large variation in the same radiant source on a radiometer and a thermopile. He used a large Bunsen burner provided with an air valve, so that the non-luminous could be at once changed to a luminous flame. He placed the burner midway between the radiometer and the pile which were about one meter apart. The radiometer was protected from the radiation of surrounding objects by a tin case, blackened on the inside, except where a circular aperture admitted the rays of the lamp and where the reflecting surface of the cover set obliquely enabled the observer to count the revolutions of the radiometer wheel. In front of the thermopile was placed an opaque screen, having an aperture of the same size as that of the radiometer case, and also a thin plate of glass to correspond to the glass of the radiometer bulb. Beginning with the non-luminous flame, Mr. Peirce counted the number of turns of the wheel of the radiometer in a minute, and also took the readings of the galvanometer; then, after rendering the flame luminous (by shutting the air valve), the same observations were repeated. A comparison of the similar values gave, of course, the relative radiation of the non-luminous and the luminous flame as measured by the radiometer on the one side and the thermopile on the other.

	Radiometer.	Thermopile.
1.	0·343	0·287
2.	0·309	0·380
3.	0·248	0·283
4.	0·267	0·325
5.	0·277	0·350
6.	0·367	0·250
7.	0·394	0·304
Mean,	0·315	0·311

While, therefore, there was quite a large variation between the several observations, as might be expected with such a variable source as a Bunsen flame, yet the close agreement of the averages showed conclusively that with the radiometer, as with the thermopile, the effect caused by the rays of light must arise solely from the change of temperature thus produced. It will be noticed that—as measured by either instrument—the radiation of the luminous flame produced only about three times the effect obtained from the non-luminous flame; while a photometric comparison made at the same time showed that the illuminating power of the first was at least a thousand times greater than that of the second. Two separate experiments gave 1080 and 1079 times greater respectively.

In this notice we have been able to refer to only a few of the salient points presented in recent articles on the radiometer, and it will of course be understood that our limits prevent us from even alluding to a large number of other very interesting observations bearing on the subject. J. P. C., JR.

Newport, August 3d, 1877.

II. GEOLOGY AND MINERALOGY.

1. *Gravel deposits referred to the Drift, in Boone County, Kentucky.*—Mr. GEORGE SUTTON states (Proc. Amer. Assoc., 1876, p. 225), that on the highest part of the table-land in Boone County, Kentucky, 450 to 500 feet above high-water mark in the Ohio, there are extensive deposits of gravel, some of which is cemented into a firm conglomerate. Similar accumulations occur at a height of about 100 feet above the same level near the mouth of Wolper Creek, and a bluff of it at this place has a height of 72 feet. It here blends with a stratified terrace formation which extends for six or seven miles along the river and is in some places over a mile in width. The material is unstratified, small pebbles and large angular bowlders being mingled in confusion. Near this part of Kentucky, the Great Miami and the White Water rivers, coming from the north, empty into the Ohio, where the river makes a sudden bend to the southeast, forming an acute western angle of the great North Bend. A line drawn from the valleys of these rivers across this acute angle intersects the drift conglomerate at Wolper Creek. Along this line, behind hills east of Petersburgh, Kentucky, there is an ancient valley of the Ohio, three to four miles long and half a mile broad, cut out of the rocks, which is now above the highest floods of the river. The drift accumulations are attributed to glacier ice coming down the Miami and White Water valleys, and crossing the Ohio valley, carrying drift material for deposition beyond. The author supposes that there may have been ice obstructions in the Ohio below, to have favored the transfer across; but if the glacier was the wide-spread northern glacier, extending across into Kentucky, the obstructions would hardly have been necessary. North of the Ohio the drift occurs nearly opposite Loughery Island, and at the mouth of Hogan Creek, at about the same height as the river-terrace formation in Kentucky. That of Hogan Creek consists of laminated clay and loam with very little gravel, and, as the author remarks, it was evidently formed away from the current of the Ohio River.

2. *Gravel Ridges in the Merrimack valley.*—Mr. G. F. WRIGHT describes the gravel ridges connected with the Quaternary of the Merrimack valley, in the vicinity of Andover and both south and north of that place, in the Proceedings of the Boston Society of Natural History for December, 1876. At Andover there are three such ridges, at a height of 82, 90, and 132 feet above the bed of the river, the highest being most remote from the stream. They are often only wide enough at top for a foot path. The courses of the ridges are more or less tortuous, and they are frequently broken into hills among which are often depressions occupied by water. They consist of sand, gravel and water-worn stones, and stones from a few inches to two feet through, and they are not in all parts stratified. The coarse material is as

likely to abound near the top as at the bottom. The material overlies the "bowlder clay" or "till" of the region. These ridges are part of what are referred to as "Kames" by Mr. W. Upham in a paper noticed on page 156 of this volume. They are regarded by Mr. Wright as depositions directly from the glacier during its dissolution, modified afterward by the water which, especially in the summer months, would have flowed freely, over, beneath and from the foot of the glacier.

3. *On the supposed Fossil Tracks called Protichnites and Climatichnites;* by Professor E. J. Chapman.—The Potsdam sandstone of Beuharnois and Vaudreuil, Canada, near the junction of the St. Lawrence and Ottawa rivers, and the same formation in the vicinity of Perth, Canada, afforded the *Protichnites*, four species of which were made out by Professor Owen. Professor Chapman, of Toronto, concludes, from his examination of them that they are impressions of large fucoids. This view he regards as strengthened by the occurrence of the *Protichnites* at Perth along with the impressions known as *Climatichnites.* The latter have the form of a band five to six inches wide and several feet in length, with transverse series of narrow parallel ridges, an inch and three-quarters apart, which he believes cannot be explained satisfactorily, except on the supposition of their having been the impressions of large fucoids. Professor Chapman therefore suggests a change in the names to *Protichnides* and *Climatichnides.—Canadian Journal*, July, 1877.

4. *Glaciers of the Swiss Alps in the Glacial era.*—Mr. A. Favre has prepared a chart containing the results of his study of the older glacial phenomena of the Alps. It is on a scale of $\frac{1}{250000}$. He states that the contours of five principal glaciers proceeding severally from the Swiss valleys of the Rhine, the Aar, the Reuss, the Linth and the Rhine, have been distinguished and their limits, as nearly as obtainable, have been laid down. The thickness of the glaciers, as deduced from the erratic blocks along the upper limit was from 1,200 to 1,600 meters. From the distribution of bowlders, the pitch of the upper surface of the ancient glaciers has been ascertained to be about thirty feet in 1,000, in the narrow valleys, while elsewhere it was more gentle; and in some places the surface was, for 50 kilometers in length, horizontal or nearly so. This state of things gives to the ancient Swiss glaciers, as he remarks, a close resemblance to those which now cover Greenland and Spitzbergen.—*Verhandl. Nat. Ges. Basel*, 1875–76, p. 136.

5. *The Geology of New Hampshire.* C. H. Hitchcock, State Geologist, J. H. Huntington, Warren Upham, and G. W. Hawes, Assistants. Part II, Stratigraphical Geology. 684 pp. Royal 8vo, with many maps, plates, and sections. Concord, 1877. —A notice of this Report is deferred to another number.

6. *Lithology of the Adirondacks.*—Professor A. R. Leeds has described, in the American Chemist for March, rocks from the Adirondacks collected by him in Essex County and mostly in the

valley and township of Keene. He adopts for the rocks, which Hunt showed to consist of feldspar identical with or near Labradorite along with hypersthene or a related augitic or hornblendic mineral (and more or less of magnetite or menaccanite), the name norite, and uses the terms hypersthenic norite, hornblendic norite, pyroxenic norite, for varieties. He gives the specific gravities of forty-four varieties of norites, which vary from 2·67 to 3·459, the proportion of the feldspar to the amphibolic species and menacanite determining it. The labradorite, from the norite forming the mass of Mount Marcy afforded him on analysis—

SiO_2	AlO_3	FeO_3	FeO	CaO	MgO	Na_2O	K_2O	H_2O	TiO_2
54·47	26·45	1·30	0·66	10·80	0·69	4·37	0·92	0·53	undet.=100·19

giving the quantivalent ratio for the protoxides, sesquioxides and silica, 1·13 : 3 : 6·83. Another analysis was made of a waxy felsitic variety, from the same place, which afforded very nearly the same result.

Professor Leeds gives also an analysis of a doleryte from the region, and others of the pyroxenic portion of the Mount Marcy norite. He also gives the characters afforded by thin slices of some of the rocks.

7. *On a new method of determining the species of Feldspars contained in rocks*, by Dr. J. Szabó, Professor of Mineralogy and Geology in the University of Budapest, Hungary. 88 pp. 8vo; with eleven wood-cuts and five colored plates. Budapest, 1876.—Professor Szabó states, in the opening of his memoir, that his new method of determining the feldspar species is based upon the well-known papers of Bunsen entitled "Löthrohrversuche" and "Flammenreactionen." This method, to the elaboration of which he has devoted four years of study and experiment, is based, first, upon the accurate determination of the degree of fusibility, and, secondly, upon the degree of coloration of the flame, observed under certain conditions, from which the amounts of sodium and potassium present are estimated. For the detailed description of the methods employed in the different experiments reference must be made to the paper itself. The main points are as follows: The only articles of apparatus needed are: an ordinary Bunsen lamp; a fine platinum wire fastened in a short piece of glass tube and having a small loop on the free end; and a support with an arm, adjustable at any height, to hold this glass tube. The small fragment of mineral of the size of a mustard seed, supported on the loop in the wire, is brought slowly into the flame of the Bunsen lamp at a height of five millimeters, and allowed to remain there one minute, and the amount of coloration due to sodium, or potassium (observed with cobalt glass), is noted. After removal from the flame the extent of fusion and character of the fused mass are observed. The same assay is then introduced a second time into the point of fusion of the Bunsen flame, the lamp now having its chimney on, and the same points noted as before. Finally the same piece of feldspar is moistened with distilled water and put into powdered gypsum, and thus covered it is introduced into the

hottest part of the flame and allowed to remain two minutes; the alkalies, now converted into sulphates, color the flame more distinctly than before, and this effect is duly noted.

Professor Szabó gives a general scale of fusibility containing eight degrees from quartz (0) to antimonite (7), and a special scale of six grades for the different feldspar species; he distinguishes the character of the fused products in the case of the feldspars according as a clear, milky or blebby glass, or a gray, white or blebby enamel, is obtained; he also gives large colored plates exhibiting the intensity of color, yellow and violet, corresponding, as found by experiment, to certain percentage amounts of sodium and potassium respectively. By means of these he is able to determine, within certain limits, the amount of the alkalies present in a given feldspar, and thus to determine the species.

This method doubtless requires considerable skill in manipulation, and also extended experience in the application of the delicate tests described. The end aimed at, however, is so important a one—especially in view of the tendency now prevalent to confound all the triclinic feldspars under the general term "*plagioclase*"—that it is worthy of much time and labor, and Professor Szabó deserves the thanks of lithologists for the care and minuteness with which he has worked out his results. E. S. D.

8. *Brief notices of some newly described minerals.*—*Venerite* occurs as a greenish earthy-looking "clay-ore" in irregular layers in the schists connected with the magnetite of Jones Mine near Springfield, Berks County, Pennsylvania. The purer portions have a pea-green or apple-green color when moist, becoming greenish-white on drying, when the mass falls to powder. This powder is seen under the microscope to consist of minute, transparent shining scales mixed with a little quartz and magnetite. An analysis made by Mr. G. W. Hawes, upon material purified by careful washing, gave:—$\mathrm{SiO_2}$ 28·93, $\mathrm{\bar{A}lO_3}$ 13·81, $\mathrm{\bar{F}eO_3}$ 5·04, FeO 0·27, CuO 16·55, MgO 17·47, $\mathrm{H_2O}$ 12·08, insoluble sand 6·22 = 100·37. After deducting the insoluble matter the composition becomes:—$\mathrm{SiO_2}$ 30·73, $\mathrm{\bar{A}lO_3}$ 14·67, $\mathrm{\bar{F}eO_3}$ 5·35, FeO 0·29, CuO 17·58, MgO 18·55, $\mathrm{H_2O}$ 12·83 = 100. The quantivalent ratio for $\mathrm{R : \bar{R} : Si : H = 3 : 4 : 6 : 4}$, "which puts the mineral, if it be a homogeneous substance (as its microscopic character would indicate) among the chlorites." (Dr. T. Sterry Hunt, in a pamphlet entitled "Description of a Double Muffle Furnace by Professor B. Silliman, and A new ore of Copper and its metallurgy, by Dr. T. Sterry Hunt; Philadelphia, Dec. 30th, 1876.)

Uranocircite occurs in quartzy veins in the granite of Falkenstein, Saxon Voigtland; it has long gone by the name of autunite which it closely resembles. Specific gravity 3·49–3·56 (autunite 3·05–3·19). Optically biaxial; apparent angle of axes about 15°–20°. An analysis by Winkler gave: BaO 14·57, $\mathrm{UO_3}$ 56·86, $\mathrm{P_2O_5}$ 15·06, $\mathrm{H_2O}$ 13·99 = 99·88, which corresponds to the formula $\mathrm{BaU_2P_2O_{12}+8H_2O}$ or $\mathrm{2(UO_2)_3P_2O_8+Ba_3P_2O_8+24nq.}$ (Dr. A. Weisbach, *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen*, 1877.

Sphærocobaltite occurs in spheroidal forms with roselite, at Schneeberg, Saxony. Structure coarsely radiated; the spherical surface under the microscope is found to be made up of minute rombohedral crystals; color peach-red; hardness = 4; specific gravity = 4·02–4·13. B.B. becomes black on ignition in closed tube. Dissolves with effervescence in warm hydrochloric acid. On analysis gave Winkler CoO 58·86, CaO 1·80, FeO_3 3·41, CO_2 34·65, H_2O 1·22 = 99·94, or, deducting the hydrated iron oxide CoO, 64·25, CO_2 35·75 = 100. This corresponds to the formula $CoCO_3$, which requires : CoO 63·06, CO_2 36·94 = 100. (Weisbach, l. c.)

Dysanalyte. Found in cubical crystals in granular limestone of Vogtsburg in the Kaiserstuhl; these crystals have long gone by the name of "perofskite." Specific gravity = 4·13. An analysis gave Knop: Cb_2O_5 22·73, TiO_2 40·57, FeO 5·70, MnO 0·42, CeO 5·58, CaO 19·36, MgO tr., Na_2O 3·50, K_2O tr., F tr., AlO_3 tr., SiO_2 2·31 = 100·17. This agrees closely with the formula $6RTiO_3 + RPb_2O_6$, when R = Fe, Ce, Ca, Na_2, etc. The mineral is named *dysanalyte*, in consequence of the difficulties met with in its analysis. (Knop, *Zeitschrift für Krystallographie*, i, 284, 1877.) E. S. D.

III. BOTANY AND ZOOLOGY.

1. *Rapid Growth.*—A. W. BENNETT says, of a plant of *Vallisneria spiralis:* The first flower-bud made its appearance in my aquarium this year on July 1st, the pedicel being at 3 P. M. apparently about 1·5 inch long. On the 3rd, at 4 P. M., the base of the bud just touched the surface of the water, and the pedicel was about 7 inches long. At 1 P. M. on the 7th (an interval of ninety-three hours), it had reached the astonishing length of 43 inches. The bud was then still closed, and the flower-stalk quite straight, i. e., not showing yet any tendency to coil. At 10 A. M. on the 9th the length was 45·5 inches, the flower being then open, and the lower half of the flower-stalk so strongly undulating that it was almost impossible to straighten it. At 11 A. M. on the 10th it had reached its ultimate length of 48 inches, the undulation of the lower portion being more strongly marked.

2. *Evolutionary Law as illustrated by Abnormal Growth in an Apple Tree.*—Mr. THOMAS MEEHAN exhibited some branches of a "Smoke-house" apple tree, which had the cluster of flowers at the end of a young shoot, flowering after the leaves and growth had matured, instead of blooming in spurs early in spring, and simultaneously with the expansion of the leaves, as in ordinary cases. There were numerous instances of the normal and abnormal growths on the same tree, the abnormal ones flowering about six weeks after the normal ones, but both classes maturing the fruit at about the same time in the fall.

The point he wished particularly to draw attention to was that when there was a change in one important character, there was often change in others making a complete set of characters which need nothing but permanence to be regarded as specific. For instance, the fruit from these terminal clusters was as unlike the normal "Smoke-house" as it was possible to be. The fruit stems were very long and slender, and the fruit flattened—what pomologists term oblate. It might further be noted that this change was not a change by gradual modification through seminal agency; but a leap, and from a tree that had always produced flowers in the normal way. There was apparently no more reason why the law, whatever it may be, that operated on this one tree might not under some circumstances operate on all the trees in the orchard, or on other wild trees in native places of growth, or on the individuals of a whole district, as well as on a single tree. It was such illustrations as these which made the doctrine of evolution in some form an absolute certainty.—*Proc. Acad. Nat. Sci. Philad.*, 1877, p. 132.

3. *Remarks on the Yellow Ant.*—Professor LEIDY remarked that recently while seeking certain animals beneath stones in the woods near Philadelphia, he had had the opportunity of observing the Yellow Ant, *Formica flava*, in possession of large numbers of other insects. This fact, in itself common enough, in one respect, was new and of special interest to him, and may be so to others. In one instance a comparatively small colony of the Yellow Ants had three different insects in their possession, consisting of a species of *Aphis*, a *Coccus*, and the larva of an insect, probably Coleopterous. The Aphides were kept in two separate herds, and these were separated from a herd of Cocci. The larva was in the midst of one of the former herds. In a larger colony of the Yellow Ants, there was a herd of Aphides which occupied the under part of one margin of the stone and was almost ten inches long by three-fourths of an inch in breadth. The same colony also possessed a separate herd of Cocci, closely crowded and occupying almost a square inch of space. In both colonies the *Aphis* and the *Coccus* were the same. The *Aphis* is pale yellow with white tubercles on the dorsal surface of the abdominal segments. The *Coccus* is of a dark-red hue. Both Aphides and Cocci, with few exceptions, adhered to the under surface of the stones, and were not attached to roots. They appeared to be carefully attended by the ants, which surrounded them. The larva alluded to was almost six millimeters long, was covered on the back with a thick white cotton-like secretion. It was also carefully attended by the ants, which were frequently observed to stroke it with their antennæ. The Aphides and Cocci were all in good condition, but without visible means of subsistence excepting the neighboring grass roots partially extending into the earth beneath the stones, to which it is probable they were at times transferred by their masters.—*Proc. Acad. Nat. Sci.*, 1877, p. 145.

4. *Sexual Dimorphism in Butterflies.*—Mr. S. H. Scudder, in an article on sexual dimorphism in Butterflies—to which special kind of dimorphism he applies the term *Antigeny*—states that it is not the male but the female that departs from the normal type of coloring of the group to which the species belongs; while it is

the male that shows divergences from the type in structural characters. These structural divergences in Butterflies appear in the wings and the legs, and sometimes in the antennæ. Mr. Scudder knows of no example in which the male alone diverges from the general plan of coloration belonging to the group.—*Proc. Amer. Acad.*, 1877.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Narrative of the North Polar Expedition, U. S. Ship Polaris, Captain Charles Francis Hall commanding.* Edited under the direction of the Hon. G. M. ROBESON, Secretary of the Navy, by Rear Admiral C. H. Davis, U. S. N., United States Naval Observatory. 696 pp. large 8vo. Government Printing Office, Washington. 1876–77.—The melancholy interest which attaches to the death of the enthusiastic explorer, Hall, just as he was seemingly about to realize his life-long hopes, is increased by the reflection that the distinguished officer, to whom was entrusted the preparation of this narrative, was himself called away by death while his task was almost complete. The final chapters were consigned by him to the editorial care of Professor Nourse of the National Observatory. This volume is what its title declares—a narrative of the Polar Expedition from its inception in 1870 until the "Frolic" brings the survivors of the party to Washington, on the 5th of June, 1873, after experiences which must ever be considered memorable, even among the almost incredible trials and heroisms of Arctic exploration. The closing chapters of the narrative recite the cruises of the Juniata and Tigress for the rescue of the Polaris and her crew, the examination of the icefloe, and the Buddington Parties, with the Report of the Board of Enquiry. The volume also contains a translation of the report made to the Royal Geographical Society of Paris, April 21, 1875, by M. V. A. Malte Brun, awarding the Roquette gold medal to the memory of Hall in consideration of eminent services in Arctic exploration, which medal was sent to the family of the unfortunate explorer; the instructions of the National Academy of Sciences; the correspondence between the British Admiralty and the U. S. Navy Department in relation to the stores left by the Polaris Expedition on the west coast of Greenland; the Journals of Mr. H. C. Chester and Captain Geo. E. Tyson while on boat journeys, June and July, 1872; and lastly a list of the Journals used in the preparation of the Narrative of the Polaris Expedition.

The scientific results of the expedition have been worked up by Dr. Bessels, under the supervision of the Smithsonian Institution, in three volumes, the publication of which may be shortly expected.

This narrative is illustrated by thirty-eight full page wood engravings from original sketches by Mr. Emil Schumann and Dr. Emil Bessels, painted in oil by Mr. J. H. Morgan and photographed on wood by Mr. Smilie. There are also eighteen tail pieces from original sketches, two photolithographs, a steel portrait of Captain Hall, and a steel engraved frontispiece of the Polaris.

It is a pleasure to know also that Professor Nourse is now engaged in preparing for publication Captain Hall's Journals during his second expedition, 1864–69, in obedience to a resolution introduced into the U. S. Senate, February 6, 1877, by Mr. Sargent. B. S.

2. *The American Meteorologist*, JOHN H. TICE, Editor. In monthly numbers of 32 pages, 8vo. Saint Louis, Missouri.—The second volume of this Journal, consisting of six monthly numbers, commenced with January of the current year. The author holds peculiar views with regard to meteorological and other phenomena, and their causes, and presents them in his Monthly. Facts are, in his opinion, in "irrepressible conflict," as he expresses it, with ordinary physical theories.

3. *The American Journal of Pure and Applied Mathematics.*—Under this title, a much needed addition to the scientific journals of the country, will soon be made, under the auspices of the Johns Hopkins University. The editors announced are: J. J. SYLVESTER, BENJAMIN PEIRCE, SIMON NEWCOMB, H. A. ROWLAND, and WM. E. STORY, the first, "Professor of Mathematics in the University, bearing the title of Editor-in-Chief," and the last being "Associate-Editor-in-Charge." Four numbers in quarto, will for the present be issued annually, making a volume each year of 384 pages. The price is five dollars a volume. The first number will appear in January, 1878. Subscriptions and contributions should be addressed to WILLIAM E. STORY, Johns Hopkins University, Baltimore, Maryland.

4. *Publications of the Cincinnati Observatory.*—Two numbers —2 and 3—have recently been issued in octavo. No. 2, eighteen pages, contains Micrometrical Measurements of 176 double and triple stars, observed with the 11-inch reflector of the Observatory by O. M. Mitchell; Cincinnati, 1876; and No. 3, thirty-four pages, bears the title, Micrometrical Measurements of 166 double and triple stars, during the years 1875–76, under the superintendence of Ormond Stone, A.M., Director, Cincinnati, 1877.

5. *Two New Meteoric Irons.* (Letter to the Editors.)—I have had lately sent to me two new meteoric irons, one from Casey County, Kentucky, and the other from Dalton, Whitfield County, Georgia. Descriptions and analyses of these will be published shortly. J. LAWRENCE SMITH.

6. *Table of Logarithms.* — M. GAUTHIER VILLARS has published in Paris a volume of logarithms, containing tables for all numbers from 0 to 434,000,000,000 with twelve decimals, by M. Namur, Secretary of the Ecole Moyenne of Thuin (on the Sambre, Belgium). This wonderful volume, selling at three francs, has been printed by order of the Royal Academy of Sciences of Belgium.—*Nature*, July 5.

7. *Tenth Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology.* Presented

to the President and Fellows of Harvard College, June, 1877. Vol. II, No. 1, 168 pp. 8vo. Cambridge, 1877.—A paper, by Dr. C. C. ABBOTT, describes the occurrence of what appear to be flint chippings in undisturbed gravel deposits, only partially stratified, of the Delaware River valley, near Trenton, New Jersey. The stone is a hard or indurated argillite, somewhat fusible before the blowpipe; but in one case, flint. Bowlders eight or ten feet in diameter occur over the surface. Mr. Abbott regards the material as of Glacial origin, and the relics, as those of man of the Glacial era. This paper is followed by another, by Professor N. S. SHALER, on the same relics and deposits, which states that he accompanied Dr. Abbott over the region, and obtained from the beds two of the supposed relics, and concludes with the remark that "if these remains are really those of men, they prove the existence of interglacial man on this part of our shore."

This Report contains also papers on the exploration of Ash Cave in Benton, Hocking County, Ohio, and on explorations of mounds in Southeastern Ohio, by Professor E. B. ANDREWS; on the exploration of a mound in Lee County, Va., by LUCIEN CARR, Assistant Curator in the Museum; and on the Art of War and Mode of Warfare of the Ancient Mexicans, by AD. F. BANDELIER.

Professor Andrews describes instruments, beads, and other ornaments of copper, from the mounds examined by him. One of the mounds (W. Connett's in Dover, Athens County, Ohio) is spoken of as "of great scientific value, because by it we prove that the mound-builders sometimes practised cremation."

In the paper by Mr. Carr, on the Virginia Mound, it is stated that among the relics obtained from it, Mr. J. A. Allen identified the bones of the *Caribou*, and remarked that "this is farther south than bones of the Caribou have hitherto been found."

8. *Kinetic Theories of Gravitation;* by WILLIAM B. TAYLOR. From the Smithsonian Report for 1876. Washington. Government Printing Office. 1877. pp. 78, 8vo.—This is a valuable historical *résumé* of the various attempts that have been made, by the most eminent philosophers, to account for the phenomena of gravitative attraction, from the time of Newton to the present day. The sketch is concluded by a vigorous criticism of the leading theories, in which the author, passing over "the consideration of the *statical* method of explaining gravitation by pressure," finds that "*kinetic* systems are essentially of two classes, the hypotheses of emissions or corpuscles, and the hypotheses of fluid undulations," and proceeds to show "that neither form of either hypothesis can satisfy the two Newtonian conditions of a scientific theory—*verity* and *sufficiency*." A. W. W.

Vacher's Primer of Chemistry. Lindsay & Blakiston, Philadelphia.

OBITUARY.

TIMOTHY ABBOTT CONRAD.—Dr. CONRAD died on the ninth of August, at the residence of his brother-in-law, Mr. T. Abbott, Trenton, New Jersey. He was son of the late Solomon Conrad, of the University of Pennsylvania, and was born in 1803.

His scientific labors began early in life and were continued up to the present year. They were devoted especially to the study and description of recent shells and the fossil shells of the Tertiary and Cretaceous formations of the United States; and in the Tertiary species they exceed in importance those of any other American Paleontologist excepting Mr. Meek. As early as 1832 he published the first number of an illustrated work on the "Fossil shells of the Tertiary formation," which, however, was never completed; and in 1831 began his "American Marine Conchology," which he carried to 72 pages and 17 plates. Later his papers were published from time to time in this Journal, and in the Publications of the Academy of Sciences of Philadelphia; the first communication to this Journal appearing in 1833, and the last in February, 1877. Memoirs by him are also to be found in the reports of various surveying expeditions. Between 1835 and 1841 he issued thirteen numbers of a "Monography of the Family Unionidæ," with many colored plates. In part of his publications he was his own lithographer. During the years 1838 to 1841, Professor Conrad had charge of the Paleontological department of the Geological Survey of New York, and his Annual Reports for those years and the Journal of the Philadelphia Academy for 1842, contain descriptions of many of the species discovered—the larger part of all that were known previous to the labors of Professor James Hall, into whose hands this department fell in 1843. Some of his general geological conclusions are presented in his "Notes on American Geology," published in this Journal for 1839 (vol. xxxv, 237), in which he advocates the doctrine (which Agassiz first suggested) that the grander divisions of geological time, or abrupt transitions in life, were determined by cold intervals in the course of the earth's progress, and he points out the great fact that the Mississippi depression, as it is often called, was a consequence of the elevation of the Appalachians on the east, and of the Rocky Mountain area, late in geological time, on the west. On the first of these points he remarks that "the theory of periodical refrigeration alone can explain the sudden extinction of whole races of animals and vegetables."

Professor Conrad took a most important part in laying the paleontological foundations of American Geology—a work shared largely also by Lea and Lyell as regards the Tertiary, by Morton for the Cretaceous, and, still more largely, by Hall for the Paleozoic species, and carried forward later by other able paleontologists.

Robert Were Fox, F.R.S., died on the 25th of July, in the eighty-eighth year of his age, "having spent his long life in acts of usefulness and deeds of the purest Christian benevolence." His experiments on the temperatures of deep mines proving an increase of depth downward, on the electro-magnetic properties of mineral veins, and his construction of the first dipping needle, are among the important scientific works that have given his name a world-wide reputation. "To his latest days, in the retirement of his beautiful home, he delighted to surround himself with intellectual friends," and watched with unfailing interest the progress of scientific discovery.

APPENDIX.

ART. XXXIII.—*Notice of some new Vertebrate Fossils;* by O. C. MARSH.

THE specimens described in the present article are all from the Rocky Mountain region, and include Mammals, Birds, Reptiles, and Fishes. Among the Mammals are two Miocene Edentates, the first detected in this country, and a third species of this group from the lower Pliocene. Another Mammal of much interest is a Rhinoceros from the Eocene, the oldest known member of the family. A number of new genera are introduced, some of which have an important bearing on the genealogy of Tertiary Mammals. Among the other vertebrates is a new genus of Crocodilians from the horizon of the Wealden, and a species of *Crocodilus* from the Pliocene.

Moropus distans, gen. et sp. nov.

This genus of Edentates is based mainly upon the bones of the feet, which have been found in several individuals. These remains are quite different from the feet bones of any of the American Edentates, recent or fossil; but indicate affinities with the extinct *Ancylotherium*, from the Tertiary of Europe, which is supposed to be related to the African Ant-bear (*Orycteropus*). The specimens here described belong to a distinct family, the *Moropodidæ.*

In the type specimen of the present species, only the hind feet appear to be represented. One of the most characteristic bones is a coössified first and second phalanx. The articulation for the metatarsal is nearly in a horizontal plane, and situated on the proximal end of the upper surface of the base. It is somewhat heart-shaped in outline with the apex rounded and about equally concave in both directions, or slightly less so transversely. This articulation occupies nearly half the length of the first phalanx which is thoroughly coössified with the second. The line of junction between the bones can, however, be traced easily, and is strongly marked on the under surface by a pit or foramen entering obliquely upwards and forwards. Except near this line of junction, the surface of the bone is rather smooth. The under surface, below the articulation, is flattened. The second phalanx is less than half the length of the first, and its surface is roughened, as if by abnormal growth of bone over the surface. The length of the first phalanx is 43mm; the longitudinal diameter of the metacarpal articulation 18mm; its transverse diameter 23mm. The least transverse diameter of the bone is 21mm: its vertical diameter at the middle is 20mm. The second phalanx is broken in this specimen, its distal articular face being absent.

Associated with the above specimen, is a short bone evidently a median phalanx, with both articular surfaces well preserved and in form corresponding to each other. Proximally there are two grooves separated by an intermediate ridge, and distally two pulley-shaped ridges with a deep groove between. The length of the shaft of this bone is 23mm; its transverse diameter is 21mm proximally, and 17mm distally. Near the center of the terminal pulleys is a deep pit on each side. The greatest vertical diameter of the bone is 32mm. This bone resembles the penultimate phalanx of the middle finger of *Priodontes*, but is somewhat shorter and thinner.

These and other less characteristic remains indicate an animal somewhat larger than a tapir. They were found in the Miocene of Oregon by the Yale Expedition of 1873.

Moropus senex, sp. nov.

A second larger species of the same genus is indicated by a few remains, among which is the characteristic bone formed of the united phalanges. The proximal phalanx is considerably larger than the one above described. Its length is 52mm. The proximal articulation is oblique, and does not occupy more than one-third the upper surface of the bone. The median phalanx is well preserved, and measures 25mm in length. It is not united with the first phalanx in a line with the axis of that bone, but is inclined about 15° toward the sole of the foot. Its distal articulation is composed of two not very prominent pulley-shaped surfaces with a groove between.

Moropus elatus, sp. nov.

The largest species of this genus, now known, is represented at present by a number of bones of the posterior extremities, mainly from the feet. The peculiar duplex bone already mentioned is among them, and affords means for comparing the different species.

The proximal phalanx here measures about 90mm in length, and the medial one 40mm. The articulation for the metatarsal is more nearly vertical than in either of the Miocene species. Its median vertical diameter is 30mm; and transverse diameter

42^{mm}. The least vertical diameter of the phalanx is 28^{mm}; transverse diameter 31^{mm}. The second phalanx has a transverse diameter of 32^{mm}, and a vertical diameter of 49^{mm}, measured across the curve of the terminal pulley. The least vertical diameter is 38^{mm}.

Associated with this bone is a well preserved first metatarsal, measuring 185^{mm} in length. Its minimum transverse diameter is 25^{mm}. The proximal surface is subtriangular, with the external side of the triangle curved outward, and the other shorter sides somewhat curved inward. The external three-fourths of the surface is transverse, and occupied by a nearly flat articular surface, which rises along a vertical ridge near the inner margin of the face. Beyond this ridge, the upper part of the surface shows marks of articulation with another bone. The inner face of the bone is somewhat concave proximally; it then presents a low broad elevation, and is flattened distally. The shaft of the bone is rounded throughout. The distal articulation is hemispherical above, but presents two shallow grooves below, which are carried around so far as to become nearly horizontal. The greatest proximal diameter is 50^{mm}, and the greatest distal diameter 44^{mm}.

The proximal face of the fifth metatarsal is oblique, triangular in outline, convex vertically, and through the greater part of its tranverse extent. Its greatest vertical extent is 65^{mm}, and greatest horizontal diameter the same. The vertical diameter of the shaft of this bone is 40^{mm}, and its transverse diameter 38^{mm}. The calcaneum measures 108^{mm} from its posterior end to the vertical face for articulation with the astragalus. The vertical diameter of the shaft is 53^{mm}, and the transverse diameter 41^{mm}.

These remains are from the Lower Pliocene of Nebraska, and indicate an animal about as large as a Rhinoceros.

Amynodon, gen. nov.

The present genus is based upon a nearly perfect skull, and various other remains which belonged to the oldest representative of the Rhinoceros family yet discovered. These specimens are from the Uinta or *Diplacodon* beds, of the Upper Eocene, and about the horizon of the Paris basin. The skull is intermediate in form between that of a Tapir and a Rhinoceros, but the molar teeth are entirely of the latter type. The premolars are all unlike the molars, and the canines above and below are very large. The incisors are small, and the inner one in each jaw is lost in the present adult animal. The lower canines are placed nearly horizontal, and taken in connection with the rest of the anterior dentition, they prove conclusively that the large lower teeth, usually regarded as incisors in *Acerotherium* and many other members of the Rhinoceros family, are really canines.

The nasals in this genus are smooth, and evidently were without horns. There were four toes in front and three behind. The type species is *Amynodon advenus* Marsh, which was provisionally referred to the genus *Diceratherium* when first described.

Tapiravus rarus, gen. et sp. nov.

The paucity of Tapiroid remains in the Miocene and Pliocene lake basins of Western America is a singular fact, probably due in part to temperature, and in part to the nature of the surrounding country. The few specimens found have been referred to *Lophiodon*, a Lower Eocene genus. Various remains from these formations on the Atlantic coast and in the West show, however, that they are quite distinct from *Lophiodon* and the existing Tapir, and represent an intermediate genus, which may be called *Tapiravus*. The type species is *T. validus* Marsh, (*Lophiodon validus*) from the Miocene of New Jersey. This genus may readily be distinguished from *Lophiodon* or *Hyrachyus*, by the last upper premolar, which is similar to the adjoining molars.

A second species of this genus occurs in the Lower Pliocene east of the Rocky Mountains, and remains were collected there by the writer in 1873. The most characteristic specimen obtained was an upper molar tooth which indicated an animal considerably smaller than the living Tapir. The crown of this molar was 15^{mm} in antero-posterior diameter, and 17^{mm} in transverse diameter. It is peculiar in having the antero-exterior angle very obtuse, and less prominent than the outer cusps.

Bison ferox, sp. nov.

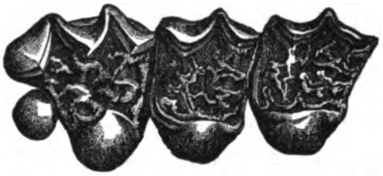
This genus has not hitherto been found in the Tertiary of this country, although not uncommon in later deposits. The Museum of Yale College contains two well preserved horn-cores from the later Tertiary, one of which was found by the writer in the lower Pliocene of Nebraska. This is quite as low as the genus has been found in the Old World. This specimen indicates an animal much larger than the existing Bison, and having very powerful horns. The specimen preserved was over 500^{mm} in length, when complete. The radius of the inner curve measures about 400^{mm}. The largest end has a diameter of 125^{mm}, and the smaller, at a distance of 300^{mm}, measures 77^{mm}.

A second larger species, with more curved horns, is indicated by a nearly perfect horn-core from the lower Pliocene of Kansas. This species, which may be called *Bison Alleni*, in honor of Dr. J. A. Allen, of Cambridge, also had very large horns. The type specimen has its greatest and least diameters near the base, 140^{mm} and 110^{mm}. At a distance of 300^{mm} further toward the end, the diameters are 100^{mm} and 90^{mm}. The radius of the inner curvature, except for the last 150^{mm} of the length, was 350^{mm}.

The discovery of these two lower Pliocene species of Bison, suggests the probability that this form is a New World type, although it has generally been credited to the other hemisphere.

Allomys nitens, gen. et sp. nov.

Among the Upper Miocene mammals, a peculiar genus is found, which is probably related to the flying squirrels, but the teeth are somewhat like those of Ungulates. Its affinities are evidently with the Rodents, however, and it represents a distinct family, the *Allomyidæ*. The general characters of the upper molar teeth are shown in the accompanying figure, which is six times natural size. The animals of this species are all very small, hardly larger than a rat. The extent of three molar teeth is 8^{mm}. The transverse distance between the two series is, in front, 3·8^{mm}, and posteriorly, 4·4^{mm}.



The known remains of this species are all from the Upper Miocene of Oregon.

Graculavus lentus, sp. nov.

The Cretaceous deposits of the Atlantic coast and of Kansas have hitherto alone yielded remains of Birds, but these have recently been found in beds of the same age in Texas. The most characteristic specimen obtained is the distal end of a metatarsal, which differs from the corresponding bone of the toothed birds from Kansas, and may be referred provisionally to the genus *Graculavus*, the type of which is from the Upper Cretaceous of New Jersey. This specimen shows that there were three toes of nearly equal size, and also a hallux raised above the main digits.

Transverse diameter of shaft of tarsometatarsal bone	4·2^{mm}
Vertical diameter of same	3·6
Transverse diameter across distal articular faces	10·
Vertical diameter of median distal articular face	4·8

The known remains of this species indicate a bird about as large as a small duck.

Diplosaurus felix, gen. et sp. nov.

An interesting discovery recently made in the lower Cretaceous, or Wealden beds, of Colorado, is a new genus of Crocodilians, intermediate between the old Teleosaurian type and the modern *Crocodilus*. The new genus has a head and teeth very similar to the latter, but with this the ancient biconcave vertebræ. The present type species is based upon a nearly perfect skull, and a number of vertebræ belonging with it. These pertained to an animal smaller than most existing Crocodilians.

Some of the principal measurements of this species are as follows:

Length of skull on median line	255·$^{\rm mm}$
Length of skull from quadrate to end of snout	275.
Transverse diameter of premaxillaries	46·
Transverse diameter of skull, at front of orbits	90·
Transverse diameter at ends of quadrates	122·
Transverse diameter of quadrate at end	20·

A second species of this genus is apparently the *Hyposaurus Vebbii* Cope, which may be called *Diplosaurus Vebbii*.

Crocodilus solaris, sp. nov.

No Miocene Crocodilians are known from the Western lake-basins, and none have been described from the Pliocene of the same regions. One species, however, lived in the Pliocene lake east of the Mountains, and, as an indication of climate, at least, is well worthy of record. The remains preserved indicate an animal of moderate size, well protected with deeply pitted bony plates, and probably belonging to the genus *Crocodilus*.

Measurements of some of the more important remains are the following:

Length of centrum of lumbar vertebræ	42·$^{\rm mm}$
Vertical diameter of anterior articulation	25·
Transverse diameter	30·
Vertical diameter of neural canal	11·
Vertical diameter of posterior articulation	25·
Transverse diameter	30·
Transverse diameter of dermal scute	34·

These specimens were found by the writer, in 1873, on the Niobrara River in Nebraska.

Nanosaurus agilis, gen. et sp. nov.

The most diminutive Dinosaur yet discovered is represented by various portions of a skeleton recently received from the Mesozoic deposits of the Rocky Mountains. These remains indicate an animal not larger than a cat, and yet apparently fully adult. Most of the bones are hollow, and the walls thin.

The crowns of the teeth are apparently compressed, and inserted in distinct sockets. The femur has the characteristic third trochanter, and is shorter than the tibia.

The principal dimensions of this pigmy Dinosaur are as follows:

Space occupied by five teeth in lower jaw	13·^{mm}
Depth of jaw below last tooth	10·
Length of femur	63·
Distance from head to middle of third trochanter	25·
Length of tibia	75·
Least diameter of shaft	6·

The geological horizon of this unique fossil is probably Jurassic, but possibly in the lower part of the Dakota group, which I regard as the equivalent of the Wealden of Europe.

Nanosaurus victor, sp. nov.

Another small Dinosaur, which may be provisionally referred to the same genus, is indicated by portions of a skeleton found in the same region, and probably at or near the same horizon. These remains belonged to a reptile about twice as large as the one just described. The bones are equally hollow, and the walls very thin. The tibia is much more elongated, and slender. No teeth were found with this specimen. The length of the tibia was about 100^{mm}, and the diameter of its shaft at the middle 6^{mm}. A metatarsal bone measures 41^{mm} in length. The remains at present known indicate an animal about as large as a fox.

Apatodon mirus, gen. et sp. nov.

One of the most interesting specimens hitherto found in the Rocky Mountain region, is a portion of a lower jaw with the last molar in place. This fossil is widely different from anything yet described, and its exact affinities are doubtful. The fragment pertained to an animal about as large as a Tapir, and the general appearance of the specimen at once suggests the mammalian type. The tooth most resembles, in form and superior surface of crown, that of a typical Suilline. The structure of the tooth, however, is different, and the fangs are, in part at least, coössified with the jaw.

This specimen was found near a locality where Dinosaur bones were abundant, and it is possible it may belong with that group. The jaw, however, is very unlike any corresponding jaw of a Dinosaur, so far as now known. This tooth measures about 41^{mm} in length of crown; 20^{mm} in transverse diameter, and 8^{mm} in height. The geological horizon is Lower Cretaceous or Jurassic.

Heliobatis radians, gen. et sp. nov.

The most interesting fossil Fish hitherto found in the Tertiary of the west is a land-locked Ray, recently discovered in the Green River beds of Wyoming. The specimen is in excellent preservation, and shows the characters of the group most perfectly. It differs much from recent Rays, and resembles most nearly the genus *Cyclobatis* of Egerton, from the Mt. Lebanon deposits of Syria, which are probably in nearly the same horizon as the locality of the present specimen. The latter differs from *Cyclobatis* in having a much greater number of radiating digits, which entirely encircle the body, and suggested the generic name. There are also numerous dermal defensive tubercles, which are wanting in *Cyclobatis*.

The principal dimensions of this rare specimen are as follows:

Antero-posterior extent of rays	235$^{\text{mm}}$
Transverse diameter across scapular arch to bases of rays	75·
Total transverse diameter	220·
Transverse diameter of head	82·
Distance between scapular and pelvic arches	55·
Length of vertebræ at pelvic arch	2·6
Length of vertebræ in caudal region	2·

Yale College, August, 1877.

THE

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[THIRD SERIES.]

ART. XXXIV.—*On the relations of the Geology of Vermont to that of Berkshire*; by JAMES D. DANA.

[Continued from page 207.]

2. LITHOLOGICAL CONCLUSIONS: WITH SPECIAL REFERENCE TO THE USE OF LITHOLOGICAL CHARACTERS AS A TEST OF GEOLOGICAL AGE.

IT is sometimes laid down as a canon in geology that the age of a crystalline terrane or formation can be told from the kind of rock constituting it. Thorough knowledge as to the kinds that may exist in formations of the same age is the proper basis for such a canon—if it has a basis—and a test of its value. The limestone series affords important facts on this subject.

The Taconic slate-belt in the western half of the limestone area and the quartzyte group of the eastern half may be separately considered, and, afterward, the relations of the two.

1. *Taconic slate-belt or range.*

The diversity of rocks in the Taconic slate-belt is small compared with that in the Eastern or Quartzyte group.

A. *In Vermont.*—The rocks, as has been explained, are (1) *argillyte* to the north; then argillyte along the center with borders of (2) *hydromica slate* varying from a pure slaty hydrous mica to a mixture of hydrous mica with more or less quartz; (3) *chloritic hydromica slate*, in which quartz seams and veins (often chloritic) are common. Besides these, there is (4) a *hydromicaceous conglomerate*, consisting of quartz pebbles in a hydromica paste, "abundant in Ira, Middletown, Wells, Poultney and Pawlet," and the main constituent of Bird Mountain, in Ira—as stated in the Vermont Geological Report (p. 426).

B. *In Berkshire and farther south.*—There are here the same slates, but in part coarser. Also (5), a rock of gneissoid aspect, in which the mica is a pearly hydrous mica (found in the Graylock range, near Williamstown); (6) a *garnetiferous chloritic hydromica slate*, common; (7) *mica schist;* (8) *graphitic mica schist;* (9) *garnetiferous mica schist;* and (10) *staurolitic mica schist* (in Salisbury and Sharon.)*

2. *Schists of the Quartzyte group.*

A. *In Vermont.*—(1) *Hydromica slate*, which is often very fine in grain and is then called *novaculite slate;* (2) *chloritic hydromica slate;* (3) *chlorite slate or schist*, sometimes containing octahedrons of magnetite; (4) *hydromica conglomerate*, like No. 4 above; (5) *hydromica quartzyte*, all shades occurring between hydromica slate and true quartzyte; (9) greenish-gray hydromica gneiss, containing disseminated chlorite—a kind of *protogine*—the mica pearl-white, the feldspar white, seen by the writer on the western slope of the quartzyte and hydromica ridge northeast of Rutland—the rock much like the kind from near Williamstown (No. 5 above).

B. *In Berkshire and farther south.*—(1) *Hydromica slate*, more or less chloritic, and often garnetiferous; (2) *mica slate*, that is, fine-grained mica schist; (3) *mica schist*, varying in color from a dark-gray to black, the latter a fissile rock consisting largely of black mica; (4) *garnetiferous mica schist;* (5) *quartzytic mica schist.*

Varieties of gneiss.—(6) *Fine-grained gneiss*, thin bedded, the mica in very small scales and in general mostly black, the feldspar in small white grains; (7) *the same*, but thick-bedded and very hard, color mostly light gray, the rock sometimes a *contorted gneiss;* (8) *the same*, but with little mica, the color whitish, graduating into (9) *granulyte*, a granular compound of quartz and feldspar, with only traces of mica; (10) a whitish or grayish *striped gneiss* having the mica in lines of spots or in interrupted lines, looking interruptedly striped, the mica mostly biotite; (11) *granitoid gneiss*, and (12) fine-grained *granite*, the gneiss graduating into these rocks, by a loss of its schistose structure; (13) *quartzytic gneiss*, fine-grained, whitish (often yellowish from alteration of pyrite or black mica), a rock that graduates by insensible shades into laminated quartzyte; (14) *epidotic gneiss*, containing much mica, half of which is muscovite, and also small green grains of epidote; (15) *syenyte gneiss*, consisting mainly of hornblende and whitish feldspar, not common; (16) *hornblende slate*, occasional beds; (17) *pyroxenyte*, consisting of white pyroxene (at Canaan, Conn.).

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* The occurrence of staurolite as well as garnet in the mica slate of Salisbury is mentioned by Prof. Dewey, in this Journal, vol. viii, p. 7, 1824. Earlier, in vol. v, 1822, he had announced the existence of staurolite in Sheffield.

(18) *Garnet rock*, a firm tough rock of a blackish-gray color, consisting of quartz, pale-red garnet, some feldspar, magnetite and pyrite, and also minute disseminated prisms showing one lustrous cleavage which may be zoisite (from Beartown Mountain)—rare.

(19) *Feldspathic quartzyte*, the feldspar (orthoclase) sometimes in largish cleavable pieces, the decomposition and removal of which leaves the quartzyte cellular, looking like a buhrstone; (20) *micaceous quartzyte*, gneiss-like in aspect, but containing little or no feldspar. Besides these quartzytic rocks, and the common hard quartzyte, there is a laminated *calcareous quartzyte*, which is very porous when weathered, owing to the removal of the calcareous portion, and which has often on its surfaces minute crystals of brown tourmaline. Abrupt transitions occur between the laminated and hard massive quartzyte; the latter sometimes corresponding for a short distance to several successive beds of the former, or taking wholly its place in the formation.

3. *Schists along an East-and-West section of the limestone region.*

In Vermont.—The schists of a section across the limestone region from west to east in the line of Rutland, are the same nearly as occur in the Quartzyte group from north to south, argillyte being the only rock to the west not found to the east.

In Berkshire.—The remark just made for Vermont applies equally to Berkshire. Along an east-and-west section in southern Berkshire, there are, commencing to the west: argillyte, various kinds of hydromica slate, from a black glossy slate differing little from argillyte, to pale pearly slates, chloritic and garnetiferous hydro-mica slates; farther east, fine-grained mica schist and gneiss, coarser garnetiferous mica schist and staurolitic mica schist; and all the gneisses and other rocks mentioned above.

Thus the same kinds of rocks are met with on going from east to west across Berkshire as in going from north to south along the Quartzyte ranges of Vermont and Berkshire.

The above lists afford an idea of the great diversity in the crystalline rocks of the limestone series. We are now prepared for a conclusion.

Since then these rocks of the limestone series are conformable, and of Lower Silurian age; and since they were all crystallized into their present state after the Lower Silurian era had nearly or quite passed, we learn—that all the various mica and chloritic schists mentioned, and the varieties of gneiss, and also, the other rocks designated, as protogine, granulyte, hornblendic, pyroxenic, epidotic and garnet rocks, were in this case a product of a single metamorphic process, acting on deposits of Lower Silurian age; and, since this wide diversity of rocks occurs in the eastern or Quartzyte portion alone of the limestone area, they have also come from that portion of the Lower Silurian to which the Quartzyte group belongs.

Consequently, if the lithological canon is a good one, neither of the rocks in the above list can be good for distinguishing formations of any other geological era than the one here considered.

But they are useless for this unless the kinds belong exclusively to it. Now no one will claim that hydromica, mica and chlorite schists, protogine, gneisses, granite, garnet and staurolitic schists, granulyte, and the rest have been derived exclusively from Lower Silurian sediments crystallized at the close of the Lower Silurian. Hence it is clear that they are not satisfactory for identifying rocks of this or any other single age. And if so, the lithological canon, as far as the varieties of these rocks described above are concerned, is not available.

The prominent point in which the gneisses and mica schists of the limestone series in Berkshire are at all peculiar is in their fineness of grain or texture. In Connecticut and farther south, the mica schists and gneisses are coarser in crystallization than those in Berkshire; so that this feature is apparently one dependent on degree of metamorphism. Temperature and rate of cooling determine the degree of coarseness (or fineness) of granular-crystalline structure in other cases, and so should it be in the metamorphic process.

One variety of the gneiss is characteristic of the eastern portion of the region—namely, the whitish kind interruptedly banded with mica spots or lines (passing into granulyte as the mica disappears). I have not observed it in New England except near the limestone region of Western Massachusetts, Connecticut and New York. The chloritic schist and chloritic hydromica schists of the series are not distinguishable from those of many other geological regions.

The lithology of the region has still some peculiarities. These are: the absence of hornblendic granite, and syenyte; the sparing occurrence of hornblende schist and hornblendic gneiss, these rocks occurring only in beds subordinate to the mica schist or true gneiss; the absence, so far as observed, of labradorite rocks; and the certain absence of granitoid labradorite rocks (those having cleavable labradorite as a prominent constituent); the absence of chrysolite rocks, corundum-bearing rocks, and zircon-bearing rocks. Moreover, coarse flesh-colored granites and coarsely porphyritic gneiss or granite are not among the rocks mentioned.

The frequent abrupt transitions between quartzyte and gneiss is of so much interest that I may refer to it here again, and repeat that it means abrupt transitions from sand deposits to mud deposits in the old seas, just as are now common along the borders of the modern.

I may also observe, again, that the great diversity found in the crystalline rocks had nothing notable to correspond to it in the external characters of the original sediments. The hydromica and mica schists are essentially one in composition, quartz being equally a variable constituent in both; so the hydromica gneiss or protogine is nearly identical with true gneiss. A gneiss or mica schist in which the mica is black (as is commonly the case here), and a hornblendic gneiss or schist, have almost the same ultimate constitution.

In the condition of sedimentary rocks, the differences which, under metamorphism, have led to so long a list of rocks would hardly be apparent to the eye, and generally be overlooked in a description—a little difference in color, or in texture, or in proportion of sand, or in compactness, or thickness of bedding, being the chief points visible in an *unaltered* rock made of clay, mud or sand.

3. OROGRAPHIC CONCLUSIONS.

Among the orographic relations between the limestone region in Vermont and Berkshire I mention here only two.

(1.) The first relates to the positions of the rocks, and the connection between position and height.

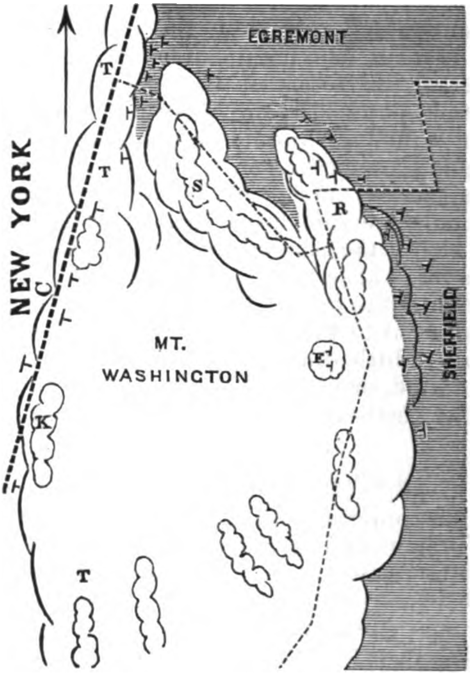
a. Along the Central slate-belt of Vermont and its continuation in Berkshire, called the Taconic range, the slates, for the most part, have a high eastward dip; and the facts show that where this is the case they are pushed over in synclinal folds (sometimes with subordinate or local anticlinals and synclinals), the axial plane of which dips eastward.

b. At intervals the slate-belt rises into peaks over 2,500 feet in height. *Such peaks occur wherever the synclinal is a broad and comparatively shallow one.*

In Vermont, this is the case in Danby Mountain, Mount Dorset or Eolus, Spruce Peak, Equinox Mountain and Mount Anthony, as illustrated on pages 346, 347, of the last volume of this Journal. The explanation is simply—that a very broad synclinal or trough holds a very large mass of mountain material; and that, on account of its magnitude, and often also its greater compactness or hardness due to the heat and pressure, it has had its height less reduced by denudation.

Berkshire, as I have already shown,* owes its highest summits, similarly, to the occurrence of broad synclinals. Graylock, the highest, is one of them; and the Berkshire Mount Washington is another.

This feature is so remarkable and so instructive in Mount Washington, that I here reproduce the outline map of the mountain, used in a former article,* on which the position, dip and strike of the limestone is given, the shaded area representing this rock, and the **T**-shaped symbols indicating the strike and dip of the rocks.* The northern portion, lettered T T, represents part of the ordinary Taconic range as it extends from Mount Washington about N. 16° E. (true), along the boundary between Massachusetts and New York, the width of which seldom exceeds a mile; while the rest of the unlined part of the map represents the area of Mount Washington, over five miles in breadth. The Taconic range, as above stated, corresponds in its narrower part to a close synclinal, with the axial plane dipping eastward. But in Mount Washington the lime-



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* This Journal, II, vi, 266. The outline of the mountain is taken from the large wall-map of Berkshire, bearing the date 1858.

stone and schists at its eastern foot dip *westward* at a small angle—usually 20° to 25° (5° to 10° in the spur R); and also *westward*, but at a higher angle, in its highest summit, Mount Everett (E, on the map, 2,634 feet above the sea-level); while on the western slope the dip is throughout eastward at an average angle of 50°, the strike N. 10°–15° E. (true). Thus the broad synclinal and its contrast with the ordinary synclinal of the Taconic range is well exhibited in the position of the rocks.

c. The great breadth of this synclinal and the size of the mountain is connected also with a *compound character in the synclinal*, another common feature in orography. As remarked in a former article, the limestone of the Egremont plain extends south in two belts between the northern spurs R and S, and S and T, and each indicates a separate anticlinal fold bringing up the limestone between synclinals of the schist. It has not been possible to follow these subordinate anticlinals southward, because the limestone is not continued far in that direction, and the summit of the mountain is under soil and cultivated farms. But yet the fact of flexure at the north end is strong reason for believing that similar flexures, if not the same continued, characterize the whole length from north to south of the mountain-mass, such a slate easily flexing under uplifting lateral pressure. This is further sustained by observations proving that other subordinate anticlinals exist on the western slope of the mountain, in the vicinity of Copake Furnace. Close to the western foot there are two nearly parallel limestone areas, parallel to the axis of the range. The inner (or more eastern) one is about a mile long, and the other about half a mile. They are separated from one another by a thin belt of hydromica slate, and the same slate exists on the other sides. The dip of the beds of limestone and slate is to the eastward 50°, the strike averaging N. 15° E. (true). They are evidently registers of local folds—anticlinal and synclinal, the former bringing up the limestone. Such flexures are not distinguishable in the schists unless sufficiently profound to bring up the limestone; for the dip is throughout to the eastward; and hence there may be many of these subordinate anticlinals and synclinals in the broad mass where there is nothing to prove it. In the memoir referred to I have mentioned some evidence that the Graylock mountain-mass, while a broad synclinal, comprises one or more subordinate anticlinals and synclinals. It is a point to be considered in the study of all mountain-masses consisting of steeply flexed rocks.

In another place in this volume, I speak of the Mt. Washington range in New Hampshire, east of the principal valley, as probably corresponding to a synclinal. I would here add that it may be a

compound synclinal, and to this owe the apparently great thickness of its andalusitic mica schists. Flexures of less span than five miles, and much less, are far more common among steeply dipping rocks than those of greater extent, and simply because, under the pressure producing such bold upturnings shaly strata cannot help flexing at narrow intervals, so as to have frequent local flexures subordinate to the larger folds.

2. The uniformity in character of the long Taconic slate-belt from Weybridge in Vermont to Salisbury and Sharon in Connecticut, and of the adjoining limestone through a still longer range, and the parallelism of the whole in position and strike with the more eastern ranges of quartzyte and schist, and parallelism, also, with the axis of the Green Mountain elevation, show that the uplifting force corresponded entirely in direction of action with that in which the Green Mountains were made, and, further, that it was sufficient in power to produce vast flexures of strata over an area of great extent. One of the summits in the Taconic range is but 600 feet lower than the highest in the more easterly Green Mountain series; and others, both in Vermont and Berkshire, are little inferior in elevation. Moreover, those of Berkshire and of the adjoining part of Connecticut far overtop all ridges to the eastward, and really constitute in those latitudes the most elevated portion of the Green Mountain system. Yet the width of the area which has been under consideration hardly anywhere exceeds twenty miles.

The magnitude of the results are strong evidence that the so-called limestone-area is really but a small part of a larger region of cotemporaneous disturbance and uplift. The true breadth of the area, as well as length—whether it reached to the Connecticut Valley on the east and to the Hudson River Valley on the west, and so had the breadth of the Appalachian disturbance of a later epoch, or whether it had narrower limits—may be ascertained by studying the stratification. Some of the results of such a study as regards Connecticut and a portion of New York I propose to give in another paper.

NOTE.—Of the two fossils from the quartzyte of Vermont, referred to on page 207 of this volume, the theca-like species—or so-called Orthoceras—has a rather close resemblance to the species of Hyolithes from the Primordial near Troy, New York, described and figured in this Journal, volume iii, for 1872, by Mr. S. W. Ford; and, were that the only species, there would seem to be ground for a strong suspicion that the quartzyte is Primordial. But the Lamellibranch shells (the other species) are even stronger evidence, in the present state of paleontological discovery, that the rock is later than Primordial. As before stated, more fossils are needed for a conclusion.

Art. XXXV.—*Address before the Department of Anthropology of the British Association, at Plymouth*; by Francis Galton, F.R.S.

Permit me to say a few words of personal explanation to account for the form of the address I am about to offer. It has been the custom of my predecessors to give an account of recent proceedings in anthropology, and to touch on many branches of that wide subject. But I am at this moment unprepared to follow their example with the completeness I should desire and you have a right to expect, owing to the suddenness with which I have been called upon to occupy this chair. I had indeed the honor of being nominated to the post last spring, but circumstances arising which made it highly probable that I should be prevented from attending this meeting, I was compelled to ask to be superseded. New arrangements were then made by the Council, and I thought no more about the matter. However, at the last moment, the accomplished ethnologist who otherwise would have presided over you, was himself debarred by illness from attending, and the original plan had to be reverted to.

Under these circumstances I thought it best to depart somewhat from the usual form of addresses, and to confine myself to certain topics with which I happen to have been recently engaged, even at the risk of incurring the charge of submitting to you a memoir rather than an address.

I propose to speak of the study of those groups of men who are sufficiently similar in their mental characters or in their physiognomy, or in both, to admit of classification; and I especially desire to show that many methods exist of pursuing the inquiry in a strictly scientific manner, although it has hitherto been too often conducted with extreme laxity.

The types of character of which I speak are such as those described by Theophrastus, La Bruyére, and others, or such as may be read of in ordinary literature and are universally recognized as being exceedingly true to nature. There are no worthier professors of this branch of anthropology than the writers of the higher works of fiction, who are ever on the watch to discriminate varieties of character, and who have the art of describing them. It would, I think, be a valuable service to anthropology if some person well versed in literature were to compile a volume of extracts from novels and plays that should illustrate the prevalent types of human character and temperament. What, however, I especially wish to point out is, that it has of late years become possible to pursue an inquiry into certain fundamental qualities of the mind by the aid of exact measurements. Most of you are aware of the recent progress of what has been termed psycho-physics, or the science of subjecting mental processes to physical measurements and to physical laws. I do not now propose to speak of the laws that have been deduced, such as that which is known by the name of Fechner, and its numerous offshoots, including the law of fatigue, but I will briefly allude to a few instances of measurement of mental processes, merely to recall them to your memory. They will show what I desire to lay stress upon, that the very foundations of the differences between the mental qualities of man and man admit of being gauged by a scale of inches and a clock.

Take, for example, the rate at which a sensation or a volition travels along the nerves, which has been the subject of numerous beautiful experiments. We now know that it is far from instantaneous, having indeed no higher velocity than that of a railway express train. This slowness of pace, speaking relatively to the requirements that the nerves have to fulfill, is quite sufficient to account for the fact that very small animals are quicker than very large ones in evading rapid blows, and for the other fact that the eye and the ear are situated in almost all animals in the head, in order that as little time as possible should be lost on the road, in transmitting their impressions to the brain. Now the velocity of the complete process of to and fro nerve transmission in persons of different temperaments has not been yet ascertained with the desired precision. Such difference as there may be is obviously a fundamental characteristic and one that well deserves careful examination. I may take this opportunity of suggesting a simple inquiry that would throw much light on the degree in which its velocity varies in different persons, and how far it is correlated with temperament and external physical characteristics. Before I describe the inquiry I suggest, and toward which I have already collected a few data, it is necessary that I should explain the meaning of a term in common use among astronomers, namely, "personal equation." It is a well-known fact that different observers make different estimates of the exact moment of the occurrence of any event. There is a common astronomical observation, in which the moment has to be recorded at which a star that is traveling athwart the field of view of a fixed telescope, crosses the fine vertical wire by which that field of view is intersected. In making this observation it is found that some observers are over sanguine and anticipate the event, while others are sluggish and allow the event to pass by before they succeed in noting it. This is by no means the effect of inexperience or maladroitness, but it is a persistent characteristic of each individual, however practiced in the art of making observations or however attentive he may be. The difference between the time of a man's noting the event and that of its actual occurrence is called his personal equation. It remains curiously constant in every case for successive years, it is carefully ascertained for every assistant in every observatory, it is published along with his observations, and is applied to them just as a correction would be applied to measurements made by a foot-rule, that was known to be too long or too short by some definite amount. Therefore the magnitude of a man's personal equation indicates a very fundamental peculiarity of constitution; and the inquiry I would suggest, is to make a comparison of the age, height, weight, color of hair and eyes, and temperament (so far as it may admit of definition) in each observer in the various observatories at home and abroad, with the amount of his personal equation. We should thus learn how far the more obvious physical characteristics may be correlated with certain mental ones, and we should perhaps obtain a more precise scale of temperaments than we have at present.

Another subject of exact measurement is the time occupied in forming an elementary judgment. If a simple signal be suddenly shown, and if the observer presses a stop as quickly as he can when he sees it, some little time will certainly be lost, owing to delay in nerve transmission and to the sluggishness of the mechanical apparatus. In making experiments on the rate of judgment, the amount of this interval is first ascertained. Then the observer prepares himself for the exhibition of a signal that may be either black or white, but he is left ignorant which of the two it will be. He is to press a stop with his right hand in the first event, and another stop with his left hand in the second one. The trial is then made, and a much longer interval is found to have elapsed between the exhibition of the alternative signal, and the record of it, than had elapsed when a simple signal was used. There has been hesitation and delay: in short, the simplest act of judgment is found to consume a definite time. It is obvious that here, again, we have means of ascertaining differences in the rapidity of forming elementary judgments, and of classifying individuals accordingly.

It would be easy to pursue the subject of the measurement of mental qualities to considerable length, by describing other kinds of experiment, for they are numerous and varied. Among these is the plan of Professor Jevons, of suddenly exhibiting an unknown number of beans in a box, and requiring an estimate of their number to be immediately called out. A comparison of the estimate with the fact, in a large number of trials, brought out a very interesting scale of the accuracy of such estimates, which would of course vary in different individuals, and might be used as a means of classification. I can imagine few greater services to anthropology than the collection of the various experiments that have been imagined to reduce the faculties of the mind to exact measurement. They have engaged the attention of the highest philosophers, but have never, so far as I am aware, been brought compendiously together, and have certainly not been introduced, as they deserve, to general notice.

Wherever we are able to perceive differences by inter-comparison, we may reasonably hope that we may at some future time succeed in submitting those differences to measurement. The history of science is the history of such triumphs. I will ask your attention to a very notable instance of this, namely, that of the establishment of the scale of the thermometer. You are aware that the possibility of making a standard thermometric scale wholly depends upon that of determining two fixed points of temperature, the interval between them being graduated into a scale of equal parts. These points are, I need hardly say, the temperatures of freezing and of boiling water respectively. On this basis we are able to record temperature with minute accuracy, and the power of doing so has been one of the most important aids to physics and chemistry as well as to other branches of investigation. We have been so accustomed, from our childhood, to hear of degrees of temperature, and our scientific knowledge is so largely based upon exact thermometric measurement, that we cannot easily realize the state of science when the thermometer, as we now use it, was unknown. Yet such was the condition of affairs so recently as two hundred years ago, or thereabouts. The invention of the thermometer, in its present complete form, was largely due to Boyle, and I find in his "Memoirs" (London, 1772, vol. vi, p. 403), a letter that cannot fail to interest us, since it well expresses the need of exact measurement that was then felt in a particular case, where it was soon eminently well supplied, and therefore encourages hope that our present needs as anthropologists may hereafter, in some way or other, be equally well satisfied. The letter is from Dr. John Beale, a great friend and correspondent of Boyle, and is dated February, 1663. He says in it:—

"I see by several of my own thermometers that the glassmen are by you so well instructed to make the stems in equal proportions, that if we could name some degrees, ... we might by the proportions of the glass make our discourses intelligible in mentioning what degrees of cold our greatest frosts do produce. . . . . If we can discourse of heat and cold in their several degrees, so as we may signify the same intelligibly, ... it is more than our forefathers have taught us to do hitherto."

The principal experiments by which the mental faculties may be measured require, unfortunately for us, rather costly and delicate apparatus, and until physiological laboratories are more numerous than at present, we can hardly expect that they will be pursued by many persons.

Let us now suppose that, by one or more of the methods I have described or alluded to, we have succeeded in obtaining a group of persons resembling one another in some mental quality, and that we desire to determine the external physical characteristics and features most commonly associated with it. I have nothing new to say as regards the usual anthropometric measurements, but I wish to speak of the great convenience of photographs in conveying those subtle but clearly visible peculiarities of outline which almost elude measurement. It is strange that no use is made of photography to obtain careful studies of the head and features. No single view can possibly exhibit the whole of a solid, but we require for that purpose views to be taken from three points at right angles to one another. Just as the architect requires to know the elevation, side view, and plan of a house, so the anthropologist ought to have the full face, profile, and view of the head from above of the individual whose features he is studying.

It might be a great convenience, when numerous portraits have to be rapidly and inexpensively taken for the purpose of anthropological studies, to arrange a solid framework supporting three mirrors, that shall afford the views of which I have been speaking, by reflection, at the same moment that the direct picture of the sitter is taken. He would present a three-quarter face to the camera for the direct picture, one adjacent mirror would reflect his profile towards it, another on the opposite side would reflect his full face, and a third sloping over him would reflect the head as seen from above. All the reflected images would lie at the same optical distance from the camera, and would, therefore, be on the same scale, but they would be on a somewhat smaller scale than the picture taken directly. The result would be an ordinary photographic picture of the sitter surrounded by three different views of his head. Scales of inches attached to the framework would appear in the picture and give the means of exact measurement.

Having obtained drawings or photographs of several persons alike in most respects, but differing in minor details, what sure method is there of extracting the typical characteristics from them? I may mention a plan which had occurred both to Mr. Herbert Spencer and myself, the principle of which is to superimpose optically the various drawings and to accept the aggregate result. Mr. Spencer suggested to me in conversation that the drawings reduced to the same scale might be traced on separate pieces of transparent paper and secured one upon another, and then held between the eye and the light. I have attempted this with some success. My own idea was to throw faint images of the several portraits, in succession, upon the same sensitized photographic plate. I may add that it is perfectly easy to superimpose optically two portraits by means of a stereoscope, and that a person who is used to handle instruments will find a common double eye-glass fitted with stereoscopic lenses to be almost as effectual and far handier than the boxes sold in shops.

In illustration of what I have said about photographic portraits, I will allude to some recent experiences of my own in a subject that I have still under consideration. In previous publications I have treated of men who have been the glory of mankind, I would now call your attention to those who are its disgrace. The particular group of men I have in view are the criminals of England, who have been condemned to long terms of penal servitude for various heinous offences.

It is needless to enlarge on the obvious fact that many persons have become convicts who, if they had been afforded the average chances of doing well, would have lived up to a fair standard of virtue. Neither need I enlarge on the other equally obvious fact, that a very large number of men escape criminal punishment, who in reality deserve it quite as much as an average convict. Making every allowance for these two elements of uncertainty, no reasonable man can entertain a doubt that the convict class includes a large proportion of consummate scoundrels, and that we are entitled to expect to find in any large body of convicts a prevalence of the truly criminal characteristics, whatever these may be.

Criminality, though not very various in its development, is extremely complex in its origin: nevertheless, certain general conclusions are arrived at by the best writers on the subject, among whom I would certainly rank Prosper Despine. The ideal criminal has three peculiarities of character; his conscience is almost deficient, his instincts are vicious, and his power of self-control is very weak. As a consequence of all this, he usually detests continuous labor. This statement applies to the criminal classes generally, the special conditions that determine the description of crime being the character of the instincts; and the fact of the absence of self-control being due to ungovernable temper, or to passion, or to mere imbecility.

The deficiency of conscience in criminals, as shown by the absence of genuine remorse for their guilt, appears to astonish all who first become familiar with the details of prison life. Scenes of heartrending despair are hardly ever witnessed among prisoners; their sleep is broken by no uneasy dreams—on the contrary, it is easy and sound; they have also excellent appetites. But hypocrisy is a very common vice; and all my information agrees in one particular, as to the utter untruthfulness of criminals, however plausible their statements may appear to be.

The subject of vicious instincts is a very large one; we must guard ourselves against looking upon them as perversions, inasmuch as they may be strictly in accordance with the healthy nature of the man, and, being transmissible by inheritance, may become the normal characteristics of a healthy race, just as the sheep-dog, the retriever, the pointer, and the bull-dog have their several instincts. There can be no greater popular error than the supposition that natural instinct is a perfectly trustworthy guide, for there are striking contradictions to such an opinion in individuals of every description of animal. All that we are entitled to say is, that the prevalent instincts of each race are trustworthy, not those of every individual. A man who is counted as an atrocious criminal by society, and is punished as such by the law, may nevertheless have acted in strict accordance with his instincts. The ideal criminal is deficient in qualities that oppose his vicious instincts; he has neither the natural regard for others which lies at the base of conscience, nor has he sufficient self-control to enable him to consider his own selfish interests in the long run. He cannot be preserved from criminal misadventure, either by altruistic or by intelligently egoistic sentiments.

It becomes an interesting question to know how far these peculiarities may be correlated with physical characteristics and features. Through the cordial and ready assistance of Sir Edmund Du Cane, the Surveyor-General of Prisons, who has himself contributed a valuable memoir to the Social Science Congress on the subject, I was enabled to examine the many thousand photographs of criminals that are preserved for purposes of identification at the Home Office, to visit prisons and confer with the authorities, and lastly to procure for my own private statistical inquiries a large number of copies of photographs of heinous criminals. I may as well say, that I begged that the photographs should be furnished me without any names attached to them, but simply classified in three groups according to the nature of the crime. The first group included murder, manslaughter, and burglary; the second group included felony and forgery; and the third group referred to sexual crimes. The photographs were of criminals who had been sentenced to long terms of penal servitude.

By familiarizing myself with the collection, and continually sorting the photographs in tentative ways, certain natural classes began to appear, some of which are exceedingly well marked. It was also very evident that the three groups of criminals contributed in very different proportions to the different physiognomic classes.

This is not the place to go further into details: indeed my inquiry is far from complete. I merely quote my experiences in order to show the way in which questions of character, physiognomy, and temperament admit of being scientifically approached, and to give an instance of the helpfulness of photography. If I had had the profiles and the shape of the head as seen from above, my results would have been much more instructive. Thus, to take a single instance, I have seen many pencil studies in outline of selected criminal faces drawn by Dr. Clarke, the accomplished and zealous medical officer of Pentonville Prison; and in these sketches a certain very characteristic profile seemed to me conspicuously prevalent. I should have been very glad of photographs to corroborate this. So, again, if I had had photographic views of the head taken from above, I could have tested, among other matters, the truth of Professor Benedict's assertion about the abnormally small size of the back of the head in criminals.

I have thus far spoken of the characters and physiognomy of well-marked varieties of men: the anthropologist has next to consider the life history of those varieties, and especially their tendency to perpetuate themselves, whether to displace other varieties and to spread, or else to die out. In illustration of this, I will proceed with what appears to be the history of the criminal class. Its perpetuation by heredity is a question that deserves more careful investigation than it has received, but it is on many accounts more difficult to grapple with than it may at first sight appear to be. The vagrant habits of the criminal classes, their illegitimate unions and extreme untruthfulness, are among the difficulties. It is, however, easy to show that the criminal nature tends to be inherited while, on the other hand, it is impossible that women who spend a large portion of the best years of their lives in prison can contribute many children to the population. The true state of the case appears to be that the criminal population receives steady accessions from classes who, without having strongly marked criminal natures, do nevertheless belong to a type of humanity that is exceedingly ill-suited to play a respectable part in our modern civilization, though they are well-suited to flourish under half-savage conditions, being naturally both healthy and prolific. These persons are apt to go to the bad; their daughters consort with criminals and become the parents of criminals. An extraordinary example of this is given by the history of the infamous Jukes family in America, whose pedigree has been made out with extraordinary care, during no less than seven generations, and is the subject of an elaborate memoir printed in the thirty-first annual report of the Prison Association of New York, 1876. It includes no less than 540 individuals of Jukes blood, among whom the number of persons who degraded into criminality, pauperism, or disease, is frightful to contemplate.

It is difficult to summarize the results in a few plain figures, but I will state those respecting the fifth generation, through the eldest of the five prolific daughters of the man who is the common ancestor of the race. The total number of these was 103, of whom thirty-eight came through an illegitimate grand-daughter, and eighty-five through legitimate grand-children. Out of the thirty-eight, sixteen have been in jail, six of them for heinous offences, one of these having been committed no less than nine times; eleven others were paupers or led openly disreputable lives; four were notoriously intemperate; the history of three had not been traced, and only four were known to have done well. The great majority of the women consorted with criminals. As to the eighty-five legitimate descendants, they were less flagrantly bad, for only five of them had been in jail and only thirteen others had been paupers. Now the ancestor of all this mischief, who was born about the year 1730, is described as having been a hunter and a fisher, a jolly, companionable man, averse to steady labor, working hard and idling by turns, and who had numerous illegitimate children, whose issue has not been traced. He was, in fact, a somewhat good specimen of a half-savage, without any seriously criminal instincts. The girls were apparently attractive, marrying early and sometimes not badly; but the gipsy-like character of the race was unsuited to success in a civilized country. So the descendants went to the bad, and the hereditary moral weaknesses they may have had rose to the surface and worked their mischief without a check. Cohabiting with criminals and being extremely prolific, the result was the production of a stock exceeding 500 in number, of a prevalent criminal type. Through disease and intemperance the breed is now rapidly diminishing; the infant mortality has of late been horrible among them, but fortunately the women of the present generation bear usually but few children, and many of them are altogether childless.

This is not the place to go further into details. I have alluded to the Jukes family in order to show what extremely important topics lie open to inquiry in a single branch of anthropological research, and to stimulate others to follow it out. There can be no more interesting subject to us than the quality of the stock of our countrymen and of the human race generally, and there can be no more worthy inquiry than that which leads to an explanation of the conditions under which it deteriorates or improves.

ART. XXXVI.—*Analyses of Cast Nickel, and Experiments on the combining of Carbon and Silicon with Nickel;* by WILLIAM E. GARD. Contributions from the Sheffield Laboratory of Yale College. No. L.

NUMEROUS analyses of commercial nickel have been published, according to which the usual impurities of this product are cobalt, iron, copper, sulphur, arsenic, alumina, alkaline earths and silica, in very varying quantities. In a few cases carbon is reported.

In text-books of metallurgy it is usually stated that the final step in the process of preparing commercial nickel is to reduce the oxide in the form of lumps or cubes without fusion by means of charcoal. According to Kerl,* the already reduced outside portion of the cube takes up carbon by contact and transfers it to the interior.' If the reduced metal be allowed to remain in contact with the coal at a high temperature, it takes up more and more carbon. It is also stated in Gmelin's Handbook of Chemistry,† on the authority of Döbereiner, that nickel takes up carbon.

The nickel plates now largely used as anodes for nickel plating are prepared by fusing commercial nickel, generally with addition of charcoal, and casting in suitable form. The process of fusion could hardly be expected to effect much change in composition beyond the removal of intermixed oxides, as alumina, alkaline earths and silica. The subjoined analyses show, however, that silica may be reduced and retained as silicon, and that a considerable amount of carbon may be present.

	No. I.		No. II.		No. III.	
	a	*b*	*a*	*b*	*a*	*b*
Carbon,	·530	·549	1·104	1·080	1·900	1·830
Silicon,	·303	·294	·130	·125	·255	·268
Iron,	·464	·463	·108	·110	·301	·318
Cobalt,	·446	·438	trace		trace	
Sulphur,	·049	·057	·266	·340	·104	·096
[Nickel],	98·208	98·199	98·392	98·345	97·440	97·488
	100·000	100·000	100·000	100·000	100·000	100·000

Carbon was estimated by the method that is generally employed in this laboratory for its determination in iron, viz: treatment with solution of perfectly neutral normal cupric chloride, or of cupric ammonium chloride, and combustion of the residue after washing on an asbestos filter. The action of cupric chloride on nickel is extremely slow, two or three weeks being required for the solution of five grams, although crushed fine in a steel mortar. The cupric ammonium chloride is a better solvent, two or three days sufficing for the solution. Of the subjects of analysis, No. I was American nickel, manufactured and cast by Jos. Wharton at Camden, N. J. A careful examination by means of Marsh's apparatus showed not the least trace of arsenic or antimony. No. II was a sample taken from a cast nickel anode used by a nickel plating establishment in New Haven. No. III, a sample taken from the same anode after it had been used in the plating bath until upward of half its weight had been removed. Solvent action had extended quite through the plate, leaving as usual a porous flexible mass retaining its original form. A comparison of Nos. II and III shows that under galvanic action the carbon, silicon and iron of the anode dissolve relatively slower than nickel, while the reverse happens with sulphur.

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* Handbuch der metallurg. Hüttenkunde, vol. iv, p. 482, 1865.

† Vol. v, p. 366, 1851.

Experiments.

It is well known that when oxide of iron is reduced by carbon at a high temperature in presence of silica, a portion of the latter is simultaneously reduced and combined with the iron. To ascertain the deportment of silicon to nickel under similar conditions, the following experiment was made. A quantity of pure nickel oxide was intimately mixed with about half its weight of finely pulverized quartz, and enough charcoal powder to effect reduction of both. The mass was made into pellets with starch paste, dried, ignited and finally, with addition of more charcoal, exposed to an intense heat for three hours. A perfectly fused metallic button was obtained, white, homogeneous in structure, soft enough to be easily drilled, having a specific gravity of 7·73. The smallest particles were not attracted by an ordinary magnet. It was found to contain

Carbon	8·90	9·50
Silicon................	6·039	6·190

In order to obtain further knowledge in regard to the amount of carbon which nickel may take up under conditions to which it is more or less exposed in the processes of manufacture and casting, half a pound of granular commercial nickel was packed in layers with charcoal in a Hessian crucible and exposed to a full red heat twelve hours. Examination of the contents of the crucible showed that no fusion had taken place. The temperature was then raised until complete fusion ensued. The resulting metal was strongly magnetic, quite soft and to a considerable extent malleable. It possessed a specific gravity of 8·04, and a fracture resembling that of fine-grained grey pig-iron, scales of graphite being plainly visible. It was found to contain:

	a	*b*
Total carbon	2·105	2·130
Graphitic carbon	2·030	1·990
Silicon	·360	----

To ascertain the deportment of nickel and cobalt toward hydrocarbon at high temperature, the following substances were placed in a platinum trough within a porcelain tube and treated with a slow current of pure dry marsh gas at a full red heat.

No. 1, thin plates of electroplate nickel—which a careful examination proved to be free from impurities. No. 2, nickel prepared by reducing pure oxide by hydrogen. No. 3, fine soft iron wire. No. 4, cobalt prepared from pure oxalate by ignition and reduction with hydrogen. These metals were first ignited in the porcelain tube with hydrogen and weighed. Three exposures to a red heat with a current of marsh gas were then made, the metals being weighed each time after cooling in the current of gas. A portion of the electro-plate nickel was used for examination after the second exposure, so that an amount equal to ·5638 grams was present at the last heat.

A condensed statement of the result is exhibited in the following tables, in which the first column contains the original weights of the metals; the second, third and fourth, the total increase in weight after successive treatments; and the fifth shows the percentage of carbon in the final resulting compounds, assuming that the gain was due exclusively to this element.

Weights of metals.		Gain in 3¼ hours.	Gain in 4¼ hours.	Gain in 6¼ hours.	% C. at close.
1. Ni,	·8597	·0067	·0823	[·0672]	10·649
2. Ni,	1·9008	·0046	·0071	·0114	5·96
3. Fe,	1·2837	·0078	·0096	·0103	·795
4. Co,	1·2697	·0758	·1680	·1857	12·758

No deposit of carbon could be detected on any part of the apparatus or on the metals at the close of the operation. The iron and nickel No. 2 were unchanged in appearance. The cobalt was somewhat blackened. It was as first prepared very porous and spongy; a part of its increase in weight may have been due to deposited carbon. Nickel No. 2 was in the form of coarse compact grains presenting comparatively little surface. The electro-plate nickel at the end of the operations had become brittle, and resembled gas carbon in color and luster; treatment with nitric acid readily dissolved the nickel, leaving a spongy mass of easily combustible carbon. A broken surface appeared under the microscope homogeneous, granular, with dull metallic luster. When ground to fine powder with water all settled rapidly and every particle was strongly attracted by the magnet. These properties seem to render it probable that the carbon was all in a combined state.

Art. XXXVII.—*On the practical use of Autography, especially for Natural History publications.* Condensed from a letter to the Christiania paper "Morgenbladet," 1875, by G. O. Sars, Professor of Zoology at the University of Christiania, Norway, and translated by J. Lindahl.

Autography is a long-known process by which manuscript, or drawings, made on common paper by means of a peculiar kind of ink, may be transferred to a lithographic stone and then printed. This simple and cheap method has, however, had hitherto a very limited practical use, and almost exclusively for the reproduction of original manuscripts, hieroglyphs, or other simple figures, for which types could not be used. In Norway it was introduced in 1873, by Dr. Lieblein, who illustrated his Egyptological work with some pages of hieroglyphic inscriptions reproduced in autography. This suggested to me the idea that the same process might answer also for representing simple zoological objects, and thus afford the means of removing one of the great impediments that too often have interfered with a free development of zoology, viz: the heavy expense connected with a production in the usual way—by lithography or copper plate engraving—of illustrations so necessary for all works on descriptive zoology. * * * There are a number of objections to the autographic process hitherto used, and these led me to experiment on the subject. I have been fortunate enough by my experiments to devise an easy method and to prove its extensive practical use, and it gives me pleasure to communicate it to the scientific world, believing that I am doing science an important service. I must add that the success of my experiments is greatly due to Mr. Fehr's warm interest and assistance.

The following is a detailed explanation of this improved autographic process. The drawing is done on common paper, not too thick (for instance common letter paper), which, on one side (where the drawing is to be made), has been coated, by means of a sponge, with a thin film of starch. As it is not well for the shading to use quite glossy paper, it is a good way to give it a granulated surface by pressing it against a lithographic stone. By using for this purpose stones with more or less smooth surface, the paper will assume any degree of smoothness required, according to the character of the drawing. The next process is to fasten the paper to a sketching board or a piece of pasteboard; the drawing is then made by means of the lithographic crayon. I use a kind of crayon containing copal ("*crayons copal*") and therefore less brittle than the common kind; and as this kind is also in other respects preferable, it had better always be used for this purpose. It can be obtained in small boxes from Monsieur Lemercier, Rue de Seine, St. Gn., 57, Paris.

The paper must be cut to the size intended for a full plate, and the drawings arranged in the same order as they will have to appear in the printed plate. The execution is exceedingly simple, and any draughtsman will easily acquire the necessary skill in the work. The method is the same as in common drawing with lead pencil, or rather crayon. The figures should, however, first be sketched in outline on common paper and then transferred to the prepared paper in the usual manner, by means of transparent paper and plumbago paper, blue paper, or, still better, red paper, the transferring being done with a lead pencil that is not too soft. The details of the figures, the shading and finer structural conditions may be drawn off-hand with the crayon on the prepared paper, after the outline has been transferred. Any correction or change in the drawing can easily be done by erasing with a fine scalpel, taking care only that the starch film be not injured. I have in this way made numerous corrections in my drawings without the slightest injury to the prints. When the plate is finished to satisfaction, it is transferred to a common smooth lithographic stone, in the following simple way. The back of the paper is moistened with water containing a small portion of nitric acid; and, after having been put for some time between moistened soft printing paper, the plate is laid, face downward, on the stone, which then for a moment is put in the press. To make more sure of it the outside of the paper may be slightly rubbed with the finger; if then the paper be stripped off, the drawing and the entire film of starch will remain on the stone, the figures being reversed. Now the stone is to be treated in the common way with gum arabic and a weak etching, and will then be ready for printing. The whole process of transferring the drawing from the paper to the stone is simple, but requires practice and great care. This should therefore be left to the charge of a professional lithographer.

It may be thought that the zoologist, by taking on himself the execution of his plates, would have his labor excessively increased. This, however, is not really so. The drawing must at all events be made by the zoologist in one way or another before the lithographer or engraver can copy them, and it is of no material difference to the former whether he makes them with lead pencil or in the above described manner. The only difference is that he must himself arrange his figures on the plates, and not, as otherwise is the practice, leave this to the lithographer; and besides, he must draw all the figures that are to go on one plate in as far as possible a continuous sequence. But this increase of labor is of small account compared with the great and essential advantages offered by this method, viz:

1. *Cheapness.*—The expenses of such a plate are reduced simply to the cost of paper and printing, and will be even less than for a page of common printed matter. Thus any zoologist who publishes his researches can illustrate his papers with any number of plates, without meeting the insurmountable obstacle of enormous expense, which too often has rendered illustration of such papers impossible.

2. *Correctness.*—It avoids the errors that come from the copying of drawings by the engraver.

3. *Quick execution.*—The author and publisher are independent of the greater or smaller expedition of the engraver. I know of many instances of the delay of important researches from this cause for years, with great detriment to the author and his works. Nothing can be more unpleasant to a working zoologist than to be forestalled in this way in his researches. All this may be avoided by using this autographic method. The plates once drawn, the whole edition can be pushed through the press within the course of a few days.

Against these great and obvious advantages it may be said that only those zoologists can avail themselves of the process who know how to draw. To this it may be answered that the knowledge of drawing is indispensable to a zoologist now-a-days. In many instances even the best draughtsman is of no use as assistant to a zoologist. In many cases, especially in microscopical researches, only a momentary flash, so to say, illuminates certain questions of importance. Such a flash must be perceived by the zoologist and so fully understood that he immediately can give a representation on paper of what he has seen, and consequently it is generally necessary that the draughtsman should be a zoologist.

Some modern zoologists have, to save expense, tried to make their drawings directly on the stone. Such a plate will of course have the value of an autographic drawing. But it requires unusual practice and a special study of the lithographic art, which can be expected of only a very small number of zoologists. It is obvious that the same result is obtained by the above described method, and in a far easier way.

ART. XXXVIII.—*On the Iodates of Cobalt and Nickel; some Specific Gravity determinations; and an Analysis of Sylvanite from Colorado*; by F. W. CLARKE, Professor of Physics and Chemistry. Numbers IV, V, and VI, of Laboratory Notes, from the University of Cincinnati.

IV. *On the Iodates of Cobalt and Nickel.*

ABOUT forty years ago Rammelsberg described the iodates of cobalt and nickel.* He dissolved the freshly precipitated carbonates of the metals in an aqueous solution of iodic acid, and, upon concentrating, obtained the salts in the form of crystalline crusts. To the cobalt salt he assigned a quantity of water of crystallization represented by 1½ molecules, while the nickel iodate was found to be monohydrated.

During the winter of 1876–1877 I put one of my laboratory students, Mr. H. B. Fullerton, at work upon the iodates, requiring him, among other salts, to prepare the two in question. Rammelsberg's mode of preparation was followed, and results somewhat different from his obtained.

When cobalt carbonate is dissolved in aqueous iodic acid and the filtered solution evaporated rapidly over a flame, Rammelsberg's iodate readily separates out, nearly the whole of the salt being deposited in a very few moments. But when, on the other hand, the solution is allowed to evaporate spontaneously, small red crystals are formed, having the composition $CoI_2O_6 . 6H_2O$. This is evidently the normal iodate, since it contains the same number of molecules of water as are found in the chlorate, bromate, nitrate, chloride, bromide, iodide, hypophosphite, hyposulphite, dithionate, selenate, and numerous other salts. Indeed, a large majority of the known salts not only of cobalt and nickel, but also of zinc and magnesium, crystallize with six molecules of water. So general does this rule appear to be that all exceptions to it ought to receive the most careful scrutiny. Even the sulphates of these metals, crystallized at temperatures above 60° C., are well known to be hexhydrated.

The new cobalt iodate differs strongly in color from the one discovered by Rammelsberg, being not a true purple, but distinctly red like the nitrate. The percentage of cobalt found was 11·10, the theoretical quantity being 11·24. Heated to 135°, the salt loses 13·73 per cent of water. Four molecules correspond to 13·95 per cent. The remaining two molecules of water could not be expelled without partially decomposing the iodate. The specific gravity is 3·6426, at 16°; and 3·6893 at

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* Poggendorff's Annalen, vol. xliv, p. 545.

21°. Rammelsberg's salt gave 5·0275 at 17°, and 4·9885 at 19°. These determinations were made by weighing in benzol with an ordinary specific gravity flask.

The iodate of nickel was prepared in a manner precisely corresponding to that which yielded the cobalt compound, and separated out in small green crystals resembling in color the nitrate. These also proved to be hexhydrated, and contained, according to Mr. Fullerton's analysis, 11·15 per cent of nickel. Theory, 11·41. Specific gravity, 3·6954 at 22°. Want of time prevented a more complete examination of this salt. An attempt was made to prepare the monohydrated iodate of Rammelsberg, but without success. I hope that at some time in the near future I may be able to get farther results concerning these and one or two other iodates, as there are various points about them which need to be cleared up. The work of Mr. Fullerton, however, shows conclusively that the true normal iodates of cobalt and nickel contain really six molecules of water of crystallization, and that they are essentially different from the salts obtained by Rammelsberg.

V. *Some Specific Gravity Determinations.*

During the past academic year the laboratory students in the University of Cincinnati have determined the densities of a considerable number of salts. Many of these salts had not been determined before; some of the determinations confirm the work of other investigators, and there are also some important corrections of older, published figures. The work has been done in connection with the regular laboratory routine, and upon the following plan. Every student, in addition to the usual exercises in qualitative analysis, has been required to do a certain amount of preparative work, and to determine the specific gravity of each substance prepared. It is understood by the student, in advance, that the substances to be chosen are as a rule those of which the density is unknown, and thus he realizes that his work is actually adding something to the data of science. In short, every student is absolutely required to determine some new fact for himself, and to determine it accurately. The work is done under my own personal supervision, and a sufficient number of checks are put upon it to render it reliable. The weighings, with a few exceptions, have been made in benzol, as in the case of the iodates already described. In three instances only were the weighings made in water. The figures, however, all refer to water as unity, taken at its temperature of maximum density.

To Mr. H. B. Fullerton, as I have already stated, was assigned the iodates. In addition to the figures for the cobalt and nickel salts, he obtained the following data.

Barium iodate, BaI_2O_6, precipitated and carefully dehydrated, 5·2179, 5·1853, 5·2855, at 18°.

Silver iodate, $AgIO_3$, precipitated, 5·4023, 16·5°. The same salt recrystallized from ammonia gave 5·6475, 14·5°.

Lead iodate, PbI_2O_6, precipitated, 6·1783, at 19°, and 6·1322, 21°. For this salt Schröder found 6·209. These three iodates were weighed in water.

Ammonium iodate, $NH_4 . IO_3$, small crystals, 3·3085, 21°; and 3·3372, 12·5°.

Mr. Fullerton also determined the specific gravities of two iodides which had previously been examined by Bödeker. CdI_2, in very beautiful pearly scales, gave 5·9857 at 12°, and 5·9738 at 13·5°. Bödeker's figure is 4·576 at 10°, making the salt *lighter* than either of the elements contained in it. This fact of itself would tend to throw suspicion upon Bödeker's results.

Bismuth iodide, BiI_3, gave Mr. Fullerton 5·9225 at 16°, and 5·8813 at 17·5°. Bödeker found 5·652 at 10°. Here again I regard Mr. Fullerton's figures as the more trustworthy.

The following double and compound cyanides were determined by Mr. W. L. Dudley.

Nickel potassium cyanide, K_2NiCy_4, H_2O; 1·875, 11°; and 1·871, 14·5°.

Potassium platinocyanide, $K_2PtCy_4, 3H_2O$, slightly moist, 2·5241, 13°, and 2·4548, 16°. The discrepancy between the two is undoubtedly due to the moisture which could not easily be removed.

Ammonium sulphocyanide, NH_4CyS, 1·299 and 1·316 at 13°.

Potassio-chromic sulphocyanide, $K_6CrCy_{12}S_{12}, 8H_2O$, 1·7051, 17·5°; 1·7107, 16°.

Potassio-platinic sulphocyanide, $K_2PtCy_6S_6$, 2·370, 19°, and 2·342, 18°.

Sodium nitroprusside, 1·6869, 25°. Schröder found 1·710 and 1·716 for this salt.

Four nitrates were determined by Mr. H. Laws.

$NiN_2O_6, 6H_2O$, gave 2·065, 14°, and 2·037, 22°.

$ZnN_2O_6, 6H_2O$, gave 2·063, 13°, and 2·067, 15°.

$CdN_2O_6, 4H_2O$, gave 2·450, 14°, and 2·460, 20°.

$BiN_3O_9, 5H_2O$, well crystallized, gave 2·823 at 13°.

This salt has also been determined by Playfair and Joule, who found 2·736. Their method of working, however, was less reliable than that with the specific gravity bottle.

The bromates were taken up by Miss E. D. Storer, with the following results.

$KBrO_3$, 3·323 at 19°. Kremers found 3·271, and Topsoë 3·218. The agreement is tolerable.

$AgBrO_3$, 5·1983, 16°, and 5·2153, 18°.

$BaBr_2O_6$, carefully dehydrated, 4·0395, 17°, 3·9918, 18°.

Hyposulphites, measured by Mr. L. T. Richardson.

CaS_2O_3, $6H_2O$, in fine crystals, 1·8715, 13·5°, and 1·8728, 16°.
SrS_2O_3, $6H_2O$, in good crystals, 2·1566, 2·1991, both at 17°.
BaS_2O_3, H_2O, precipitated, 3·4461, 16° and 3·4486, 18°.

Mr. Richardson also made a determination for potassium sulphate, getting 2·653, 18°. This agrees closely with Pettersson's figure, 2·66.

Tungstates, examined by Mr. J. L. Davis. The sodium salt was a commercial product, and was therefore first analyzed to be certain of its character. The nickel and barium salts were prepared by the well-known method of fusion.

Na_2WO_4, 4·1743, 20·5°, and 4·1833, 18·5°.
Na_2WO_4, $2H_2O$, 3·2588, 17·5°, and 3·2314, 19°.
$BaWO_4$, 5·0035, 13·5°, and 5·0422, 15°.
$NiWO_4$, 6·8846, 20·5°, and 6·8522, 22°.

Molybdates, prepared and determined by Mr. F. O. Marsh.

$BaMoO_4$, 4·6589, 17·5°, and 4·6483, 19·5°.
$SrMo_4$, 4·1554, 20·5°, and 4·1348, 21°.

Mr. C. A. Mohr worked upon phosphates and hypophosphites, as follows.

Barium hypophosphite, $BaP_2H_4O_4$, H_2O, 2·8718, 10°, and 2·8971, 17°.
Magnesium hypophosphite, $MgP_2H_4O_4$, $6H_2O$, 1·5886, 12·5°, and 1·5681, 14·5°.
Sodium metaphosphate, $NaPO_3$, prepared by igniting microcosmic salt, 2·4756, 19·5°, and 2·4769, 18°.
Potassium metaphosphate, KPO_3, prepared by igniting the monopotassium ortho-salt, 2·2639, and 2·2513, both at 14·5°.

No other hypophosphites or metaphosphates have as yet had their densities determined.

Trisodium orthophosphate, anhydrous, Na_3PO_4, 2·5111, 12°; 2·5362, 17·5.
Sodium pyrophosphate, $Na_4P_2O_7$, $10H_2O$, 1·7726, 21°. Playfair and Joule found 1·836.

The same salt, dehydrated by ignition, 2·3851 and 2·3613, 17°. Schröder's determination makes the salt 2·534, a widely different figure.

The following series of chromates was prepared and examined by Miss E. O. Abbot.

Magnesium chromate, $MgCrO_4$, $7H_2O$, finely crystallized, 1·7613 at 16°. For this salt Bödeker found 1·75, and Kopp 1·66. The higher result is more probable. In her work on this compound Miss Abbot also determined another important fact, namely that, like the corresponding sulphate, magnesium chromate loses six molecules of water readily, holding the seventh with much greater firmness. Heated to 130° the salt loses 40·21 per cent of water, the theoretical quantity being for six molecules 40·52. Heated still hotter, say to 230°, more water, but not the whole, is expelled, the compound at the same time undergoing partial decomposition. The density of $MgCrO_4, H_2O$, was found to be 2·2886 and 2·2301, at 17°.

Ammonium chromate, $(NH_4)_2CrO_4$, crystallized, 1·9138 and 1·9203, 12°. Schröder makes it 1·860 to 1·871.

Ammonium dichromate, $(NH_4)_2Cr_2O_7$, 2·1223, 16°, and 2·1805, 17°. Schröder found 2·153; a close agreement.

Sodium chromate, Na_2CrO_4, 2·7358, 12°, and 2·7104, 16·5°. The decahydrated salt, $Na_2CrO_4, 10H_2O$, was also attempted, but with poor results. A single determination came out 1·4828 at 20°, a figure probably much too low. The difficulty in dealing with this body arises from the extreme instability of its water of crystallization.

Ammonium-magnesium chromate, $(NH_4)_2Mg(CrO_4)_2, 6H_2O$, well crystallized, 1·8278 and 1·8595 at 16°. Also 1·8293 at 17°. In preparing this compound, cold saturated solutions of the separate chromates were mixed. Instantly a heavy crystalline precipitate was formed, which dissolved up again upon heating. As the solution cooled, crystals were abundantly deposited. Evidently, then, the double salt is much less soluble than either of its components.

Potassium-magnesium chromate, $K_2Mg(CrO_4)_2, H_2O$, 2·5804, 19°; and 2·5966, 19·5°. Schröder gives 2·592 to 2·608, a close agreement.

These chromate determinations fill up some important gaps in this series of salts, and help us to arrive at some interesting conclusions. Pettersson has lately shown that selenates have molecular volumes exceeding those of the corresponding sulphates by 6 for each molecule of the acid radicle. Thus, the molecular volume of sodium selenate is that of the sulphate plus 6; that of a selenic alum exceeds that of the corresponding sulphuric alum by four times 6, and so on. Upon comparing these and other chromates with Pettersson's selenates we now find that the two series of salts have approximately equal molecular volumes; the difference, if any exists, being very slightly plus for the selenates. If regularities of this kind can be thoroughly established, it will be easy, having the density of a chromate, to calculate that of the corresponding sulphate or selenate, and *vice-versa*. This connection between chromates and selenates has already been suggested by Schröder, and Miss Abbot's figures do much towards confirming it. Miss Abbot has also redetermined the density of chromic chloride, Cr_2Cl_6, on a beautifully characterized specimen. She finds 2·3572, 17·5°, and 2·3766, 16·5°. Schafarik's figure for the substance being 3·03, I redetermined it again in person, and got 2·349 at 20°. My result thus confirms those of Miss Abbot, and the question is raised whether this compound may not exist in more than one modification as regards density.

The following series of pyrophosphates was worked up by Mr. G. W. Lewis. They were prepared by igniting the double ammoniacal orthophosphates.

$Mn_2P_2O_7$, 3·5847, 20°, and 3·5742, 26°.
$Mg_2P_2O_7$, 2·598, 22°, and 2·559, 18°. Schröder found 2·22.
$Zn_2P_2O_7$, 3·7538 and 3·7574, 23°.
$Co_2P_2O_7$, 3·746, 23°, and 3·710, 25°.
$Ni_2P_2O_7$, 3·9303, 25°, and 3·9064, 27°.

Some of the corresponding pyroarsenates were prepared by Miss Helena Stallo, as follows.

$Mn_2As_2O_7$, 3·6832 and 3·6927, 23°. Also 3·6625, 25°.
$Zn_2As_2O_7$, 4·7034 and 4·6989, 21°.
$Mg_2As_2O_7$, 3·7305, 15°, and 3·7649, 18°.

Miss Stallo also determined the anhydrous trisodium orthoarsenate, getting 2·8128 and 2·8577, 21°.

The following compounds, representing various series, may be regarded as scattering.

Glucinum sulphate, $GlSO_4, 4H_2O$, 1·6743, 22°, Miss Stallo. Topsoë found for this salt, 1·725. The sample Miss Stallo worked with was slightly damp, which will account for the difference.

Potassio-chromic oxalate, $CrK_3C_6O_{12}, 3H_2O$; 2·1039, 23°, and 2·1464, 24°; E. P. Bishop.

Stannous chloride, $SnCl_2, 2H_2O$, 2·634, 24°, E. P. Bishop. The published figure obtained by Penny was 2·71, 15·5°.

Cupro-mercuric iodide, $HgI_2 . CuI$, 6·1602, 15°, and 6·1412, 13°, A. E. Heighway.

Mercuric chloride with ammonium dichromate, $HgCl_2 . Am_2Cr_2O_7 . H_2O$, in large crystals, 3·2336, 21°, and 3·1850, 18°, A. E. Heighway.

Mercuric acetate, $Hg(C_2H_3O_2)_2$, 3·2544, 22°, and 3·2861, 23°, John Hagemann.

This completes the list of determinations thus far made by my students. Sixty-three compounds are here given, forty-six among them not having been measured before. In concluding, I will give a few determinations of my own.

Potassium iodate, KIO_3. There are two published values for this salt, namely, 3·979, Kremers, and 2·601, Ditte. These vary from each other so widely that I thought it worth while to redetermine the salt, and I obtained the figure 3·802, 18°. This confirms Kremers.

Tellurium dioxide, TeO_2, 5·7559, 12·5°, and 5·7841, 14°. Schafarik found 5·93.

Tellurium trioxide, TeO_3, 5·0704, 14·5°; 5·0794, 10·5°. **Another** sample gave 5·1118, 11°.

Barium tellurate, $BaTeO_4$, feebly ignited, 4·5486, 10·5°; 4·5305, 10°. Another sample gave 4·4811, 16°. This salt, like the sulphate, becomes much denser by ignition. Unignited, but dried at 200°, its specific gravity is in the neighborhood of 4·2.

VI. *An Analysis of Sylvanite from Colorado.*

Having had occasion lately to analyze a sylvanite from the Grand View Mine, Colorado, I publish the result here, not because it contains anything novel, but because it seems to be desirable that such material should be preserved for future reference and discussion. The ore from this mine has, I believe, not been carefully analyzed before. The specimen was imbedded in quartz, associated with a little iron pyrites, and had all the usual characteristics of sylvanite.

The analysis came out as follows, after eliminating a little gangue.

Tellurium	52·96
Gold	26·39
Silver	10·55
Iron	4·45
Sulphur	5·62
	99·97

The sulphur was not estimated directly, but was calculated as pyrites to correspond with the amount of iron found. Eliminating the pyrites the analysis will stand thus.

Tellurium	58·91
Gold	29·35
Silver	11·74
	100·00

This sylvanite was kindly given me by Professor E. S. Wayne, of Cincinnati.

ART. XXXIX.—*Notes on the Analysis of Bituminous Coal;* by T. O'CONOR SLOANE, A.M., E.M., Ph.D.

THE determination of ash in coal appears a very simple matter; yet I have on several occasions found much difficulty in reaching accurate results. I traced the error finally to insufficient pulverization of the coal.

A sample of coal was reduced to powder and passed through a fine wire sieve, number sixty, or eighty, mesh. I made a number of determinations of ash, using different weights of the coal, and got the following widely discordant results:

a. From 3 grams, 6·66 p. c.; *b.* 12 grams, 3·72 p. c.; *c.* 1 gram, 4·67 p. c.; *d.* 2 grams, 4·40 p. c.; *e.* 12 grams, 2·63 p. c.

I then took all that was left of the pulverized coal, spread it out upon a piece of glazed cloth, and divided it into two parts, each of about the same weight. I did this with the usual precautions adopted in sampling, so that the coal in each half would be exactly the same. One of these parts was ignited and incinerated. Its weight was 23·9665 grams. The ash weighed ·9920 grams, or determination *f.* 24 grams nearly, 4·14 per cent. The other portion was powdered in a porcelain mortar until of a full brown color. The ash was determined in one gram of it, giving 3·90 per cent, *e.* 1 gram, 3·90 per cent.

I have since this investigation subjected any coal I was about to analyze to a fine powdering in a porcelain mortar. I am of opinion that it would be well to prolong the operation in an agate mortar, but the process is too tedious. Though the coal be reduced to a brown powder, it is still quite difficult to obtain good duplicate results. I give below some instances:

	1.	2.
Coal A	4·50 p. c.	4·00 p. c.
B	5·25	5·12
C	13·86	14·10
D	5·82	5·75

The ash I generally determine in one gram of the coal. If the crucible, in which the incineration is taking place be supported on the triangle in an inclined position, and if the lid be so placed as to direct the exterior zone of the flame into it, the operation will be greatly abridged. By looking into the crucible while over the burner it can be seen when the right position has been reached. The cake of coke will appear bright, or ignited, on the surface. From time to time it may be rubbed, or broken up if possible, with a platinum wire. Before incineration the sample should be ignited in the same crucible with the cover on.

The sulphur may be conveniently determined by fusion with the salt flux (Fresenius, Vacher's Ed., p. 127). One gram of the coal is fused with a mixture of $NaCl$ 24 grams, $NaNO_3$ 8 grams, Na_2CO_3, 4 grams. Frequently a mixture of equal parts of nitrate, and carbonate of soda is employed, sixteen parts of the mixture to one part of coal. With the salt flux the reaction is less violent, all can be at once introduced into the crucible, and immediately fused. The coal mixed with the deflagrating flux, the second described, has, on the contrary, to be thrown into the hot crucible a little at a time, so that it exacts more attention and trouble. The salt fusion, in two comparative determinations that I made, gave higher results on the same coal.

	Salt Fusion.	Deflagration.
Coal A	1·70 p. c.	1·37 p. c.
B	1·92	1·69

The specific gravity cannot be satisfactorily determined without the specific gravity bottle. By weighing lumps in air and in water all sorts of results will be obtained. I break up a sample in an iron mortar and pass it through a No. 4 or 6 sieve. I then shake it up in a finer, No. 15 or 20, sieve, so as to free it from the dust and fine particles. This seems a bad practice yet cannot well be avoided. The finely divided coal, if left in with the rest, will float on the surface of the water used in determining its specific gravity, and no amount of boiling will make it sink.

The coal thus prepared I place in a small beaker with some distilled water, and boil it. I then put the coal and water into the specific gravity flask, fill up with recently boiled distilled water, and cool it to about the temperature of the room. The last cooling is done in a beaker of water which is stirred once or twice, during the cooling, to make the water of uniform temperature. When the bottle and contents have attained this temperature, the bottle is carefully filled, the stopper put in, and the whole dried and weighed. The coal is then thrown out, the bottle filled with recently boiled distilled water, brought to the same temperature as before, and weighed. This careful reduction to one temperature is very important; by paying attention to it very close duplicates can be obtained.

The specific gravity of coal varies with the percentage of ash; yet the correspondence is not so perfect as to make the determination of the specific gravity a substitute for that of the latter constituent. As the degree of correspondence is a matter of some interest, I give below a number of parallel determinations of ash and specific gravity.

Specific gravity.	Ash.	Specific gravity.	Ash.
1·282	4·02 p. c.	1·327	7·23 p. c.
1·300	4·08	1·308	7·95
1·286	4·14	1·334	10·38
1·296	4·68	1·377	13·98
1·295	5·18	1·385	16·22
1·294	5·78		

Tracing Cloth instead of Glazed Paper.

For the purposes of sampling and pulverizing minerals, coals, fertilizers, &c., for analysis, glazed paper is generally employed. This soon wears out. I have adopted ordinary draughtsman's tracing cloth in its place. This lasts indefinitely, is just as smooth, and is much to be recommended for these purposes. In the assay laboratory, paper, used for mixing the weighed ores with the fluxes, soon wears out. Here, also, I would suggest the use of tracing cloth.

Laboratory N. Y. Gas Light Co., New York, August, 1877.

ART. XL.—*A Preliminary Catalogue of the Reptiles, Fishes and Leptocardians of the Bermudas, with descriptions of four species of Fishes believed to be new;* by G. BROWN GOODE.

IN a previous paper* I enumerated seventy-four species of fishes collected in the Bermudas in 1872. Another visit to these islands during the past winter has enabled me, with the coöperation of Mr. J. Matthew Jones, who kindly allowed me the use of his collections and note books, to increase the number to one hundred and sixty-three. Of these one hundred and forty-eight have been sufficiently studied to enable me to give their names in this preliminary list. I hope at an early day to discuss the fishes of the Bermudas in a more extended paper. Since there is a peculiar interest in the chorological relations of the members of an insular fauna, I have in a general way designated the distribution of each species by the use of letters. W. indicates the West Indian province, U. the eastern coast of the United States north of Georgia, E. the Eastern Atlantic, including Madeira, the Canary Islands and the Mediterranean, and P. the Indo-Pacific waters. These however do not show faunal relations accurately, since in this way it is impossible to distinguish those species which are resident in any particular district from mere stragglers. Those species which are peculiar to Bermuda are marked "B." and are eight in number; two of these, with *Carassius auratus*, introduced, occupy the land-locked brackish marshes. Two species, *Eucinostomus Lefroyi* and *Haliperca phœbe*, occur only in Bermuda and Cuba. The Bermudian fauna shares with the West Indies one hundred and sixteen species (or seventy-nine per cent), of which fifty-eight (or forty per cent) are peculiar to the West Indies, never having been recorded elsewhere, while a large number of others have their centers of distribution in that region, individuals having made their way in summer to the coasts of the United States or Europe. With the eastern United States, Bermuda shares forty-seven species, five of which are otherwise recorded only from our waters, all of these, viz: *Ceratacanthus aurantiacus*, *Zonichthys fasciatus*, *Lagodon rhomboides*, *Synodus fœtens*, and *Eulamia obscura*, will doubtless prove to be members of the West Indian fauna, and be found to occur in the islands adjoining the coast of Florida. With the waters of the Pacific and Indian Oceans, it has in common thirty-two species. Should *Glyphidodon cœlestinus* Solander, prove identical with *G. saxatilis*, another species will be added to this list.

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* Catalogue of the Fishes of the Bermudas, based chiefly upon the collections of the United States National Museum. By G. Brown Goode, Assistant Curator U. S. National Museum. (Bulletin U. S. Nat. Mus., No. 5.) Washington: Government Printing Office. 82 pp. 8vo. 1876.

The following are the numbers of species common to two or more faunas, the letters having significations as explained above:—B. W. U., 37; B. W. E., 36; B. W. P., 25; B. P. E, 22; B. U. E., 21; B. W. U. P., 3; B. W. U. E., 6; B. W. E. P., 7; B. W. U. P. E., 12.

The reptiles, it will be observed, are all pelagic except the lizard, which is peculiar to Bermuda and most closely related to the West African species of the genus.

CATALOGUE.

Class, REPTILIA.

Order, *Lacertilia.*

Eumeces longirostris *Cope.* Lizard. B.

Order, *Testudinata.*

Sphargis coriacea *Rond.* Leather Back Turtle.
Thalassochelys caouana *L.* Loggerhead Turtle.
Eretmochelys imbricata *L.* Hawksbill Turtle.
Chelonia mydas *Schw.* Green Turtle.

Class, PISCES.

Sub-class, TELEOSTEI.

Order, *Pediculati.*

Pterophryne picta (*Val.*) *Goode.* Devil Fish. W.
Pterophryne principis (*Val.*) *Goode.* W.

Order, *Plectognathi.*

Orthagoriscus mola (*L.*) *Schn.* Sun Fish. P. E. W. U.
Paradiodon hystrix (*L.*) *Blkr.* Sea Hedgehog. P. E. W.
Diodon novem-maculatus *Cuv.* P. W.
Chilomycterus reticulatus (*L.*) *Bibron.* Sea Porcupine. E. W.
Tetrodon rostratus *Bloch.* E.
Chilichthys Spengleri (*Bloch*) *Goode.* Swallow. E. W.
Ostracium quadricorne *L.* Cow Fish. E. W.
Ostracium triquetrum *L.* Cuckold. W.
Lactophrys trigonus (*L.*) *Poey.* U. W.
Balistes capriscus *Gmel.* Turbot. P. E. W. U.
Balistes vetula *L.* Blue Turbot. W. U.
Canthidermis maculatus (*Gmel.*) *Blkr.* Ocean Turbot. P. E. W.
Canthorhinus occidentalis (*Gthr.*) *Goode.* W. U.
Canthorhinus setifer *Benn.* var. beta. P. E. W. U.
Alutarius scriptus (*Osbeck*) *Blkr.* P. E. W.
Ceratacanthus aurantiacus (*Mitch.*) *Gill.* B. U.

Order, *Lophobranchii.*

Hippocampus antiquorum *Leach.* Sea Horse. P. E. W.
Hippocampus guttulatus *Cuv.* Sea Horse.
Syngnathus Jonesii *Gthr.* B.

Order, *Hemibranchii.*

Centriscus scolopax *L.* E. U.
Fistularia serrata *Cuv.* P. U. B.
Aulostoma maculatum *Val.* Trumpet Fish. W.

Order, *Teleocephali.*

Rhomboidichthys lunatus (*L.*) *Gthr.* Plaice. W.
Rhomboidichthys ocellatus (*Agass.*) *Gthr.* W.
Hemirhombus aramaca (*Cuv.*) *Gthr.* W.
Hemirhombus soleæformis (*Agass.*) *Gthr.* W.
Lefroyia bermudensis *Jones.* B.
Brotula barbata (*Schn.*) *Cuv.* W.
Undetermined gadoid fish.
Blennius crinitus *C. & V.* W.
Blennius (species undetermined).
Blennius (species undetermined).
Blennius (species undetermined).
Labrosomus nuchipinnis (*Q. & G.*) *Gill.* E. W. U.
Salarias texilis *Q. & G.* W.
Gobius soporator *C. & V.* Molly Miller. E. W.
Dactylopterus volitans (*L.*) *Cuv.* Flying Gurnard. E. W. U.
Scorpæna Plumieri *Schn.* Prickly Hind. W. U.
Scarus radians *Val.* Spanish Porgy. W.
Scarus Catesbyi *Lac.* W.
Pseudoscarus vetula (*Schn.*) *Gill.* Blumber. W.
Pseudoscarus quadrispinosus (*C. & V.*) *Guich.* Rainbow. W.
Pseudoscarus cœruleus (*Bloch*) *Gthr.* Gillingbore. W.
Pseudoscarus croicensis (*Bloch*) *Goode.* W.
Pseudoscarus psittacus (*L.*) *Gthr.* Parrot Fish. W.
? Pseudoscarus acutus *Poey.* Mud Belly. W.
Chœrojulis radiatus (*L.*) *Goode.* Blue Fish. W.
Chœrojulis bivittatus (*Bloch*) *Poey.* Slippery Dick. W.
Lachnolæmus falcatus (*L.*) *Val.* Hog Fish. W.
Harpe rufus (*L.*) *Gill.* Spanish Hog Fish; Spanish Lady Fish. E. W.
Julis bifasciatus (*Bloch*) *Gthr.* W.
Julis nitidissima *Goode,* (new species) 1. B.
Pomacentrus leucostictus *M. & T.* W.
Glyphidodon saxatilis *L.* Cow Pilot; Sergeant Major. E. W. U.
Eucinostomus gula (*C. & V.*) *Goode* Shad. W.
Eucinostomus Lefroyi *Goode.* Long Bone Shad. W.
Acanthurus nigricans (*L.*) *Gill.* Doctor Fish. W. U.
Sarothrodus bimaculatus (*Bloch*) *Poey.* Four-eyed Fish. W.
Sarothrodus capistratus (*L.*) *Poey.* W.
Holacanthus ciliaris (*L.*) *Lacep.* Angel Fish. W. U.
Holacanthus tricolor (*Bloch*) *Lacep.* Black Angel Fish. W.
Xiphias gladius *L.* Sword Fish. E. W. U.
Thyrsites prometheus (*C. & V.*) *Gthr.* Cat Fish. E.
Orcynus alliteratus (*Raf.*) *Gill.* Mackerel. E. P. W. U.
Orcynus thynnus (*L.*) E. U.
Auxis Rochei (*Risso*) *Gthr.* Frigate mackerel. E. P. W.
Decapterus punctatus (*Agass.*) *Gill.* Round Robin. W. U.
Trachurops crumenophthalmus (*Bloch*) *Gill.* Goggle-Eye. P. W. U.
Paratractus pisquetos (*C. & V.*) *Gill.* Jack. W. U.
Carangus (near C. falcatus). Gwelly.
Carangus carangus (*Bloch*) *C. & V.* P. E. W.
Carangus dentex (*Bloch*) *C. & V.* E. W.
Trachynotus ovatus (*L.*) *Gthr.* Alewife. P. E. W. U.

Trachynotus goreensis *C. & V.* E. W.
Naucrates ductor *L.* Pilot Fish. E. P. W. U.
Zonichthys fasciatus (*Bloch*) *Sw.* Bonito. U.
Seriola Dumerilii *Risso.* Bonito. E. P.
Coryphæna pelagica (*L.*) Risso. Dolphin. E.
Nomeus Gronovii (*Gmel.*) *Gthr.* P. E
Centrolophus (species undetermined). E.
Brama Rayi *Schn.* E.
Malacanthus Plumieri (*Bloch*) *C. & V.* Whiting. W.
Mulloides flavovittatus (*Poey*) *Gthr.* Goat Fish. W.
Hypeneus maculatus (*Bloch*) *Cuv.* Goat Fish W. U.
Holocentrum sogo *Bloch.* Squirrel. W. U.
Pareques acuminatus (*Schn.*) *Gill.* Cluck; Black Grunt. W.
Calamus megacephalus (*Sw.*) *Poey.* Goat's Head Porgy. W.
Calamus orbitarius *Poey.* Sheep's Head Porgy. W.
Sargus variegatus (*Lac.*) *Goode.* Bream. E.
Sargus argenteus *C. & V.* W.
Lagodon rhomboides, (*L.*) *Holbrook.* Spanish Porgy. U.
Pimelepterus Boscii *Lac.* Chub. E. U.
Pristipoma (species undetermined). Sailor's Choice.
Hæmylum capeuna (*Licht.*) *Goode.* White Grunt. W. U.
Hæmylum xanthopterum *C. & V.* Yellow Grunt. W.
Hæmylum macrostoma *Gthr.* Streaked Grunt. W.
Lutjanus caxis (*Schn.*) *Poey.* Gray Snapper. W.
Lutjanus buccanella (*C. & V.*). Black-Fin Red Snapper. W.
Lutjanus aya (*Bloch*) *Gill.* Red Snapper. W.
Lutjanus (species undetermined). Silk Snapper.
Lutjanus (species undetermined). Schoolmaster.
Ocyurus chrysurus (*Bloch*) *Gill.* Yellow Tail: Yelting. W.
Trisotropis undulosus (*Cuv.*) *Gill.* W.
var. quadratus *Goode*, MS. Black Rock Fish.
var. venatus *Goode*, MS. Geg.
var. rubromaculatus *Goode*, MS.
Trisotropis guttatus (*Schn.*) *Gill.* Red Rock Fish. W.
Trisotropis (species undetermined). Salmon Rock Fish. W.
Epinephelus striatus (*Bloch*) *Gill.* Hamlet; Grouper. W.
Epinephelus guttatus (*Gmel.*) *Goode.* Hind. W.
Enneacentrus punctatus (*L.*) *Poey.* E. W.
var. guativere *Goode*, MS. Coney; Butter Fish.
var. ouatalibi *Goode*, MS. Nigger Fish.
Petrometopon guttatus (*L.*) *Gill.* W.
Serranus (species undetermined). Graysby.
Serranus (species undetermined). Mutton Hamlet.
Haliperca phœbe *Poey.* Phebe. W.
Hypoplectrus puella (*Cuv.*) *Gill.* Cataphebe. W.
Rhypticus saponaceus (*Schn.*) *Cuv.* Soap Fish. E. W. U.
Undetermined percoid fish.
Elacate canadus (*L.*) *Gill.* Cubby-yew. P. E. W. U.
Apogon imberbis (*L.*) *Gthr.*
Priacanthus macrophthalmus *C. & V.* E. W. U.
Echeneis remora *L.* Suck Fish. P. E. W. U.
Leptecheneis naucrates (*L.*) *Gill.* Suck Fish. P. E. W U.
Sphyræna spet (*Hauy*) *Goode.* Barracuda. E.
Sphyræna picuda *Schn.* Sennet. E. W.
Regalecus gladius (*Walb.*) *C. & V.* Sea Serpent. E. P.
Mugil liza *Val.* Mullet. W.
Atherina harringtonensis *Goode*, (new species) 3. Russ Fry. B.
Belone Jonesii *Goode*, (new species) 2. Hound Fish. B.
Belone hians *C. & V.* Long Gar Fish. W.
Hemirhamphus Pleii *Val.* Gar Fish. W.
Exocœtus exiliens *Gmel.* Butterfly Fish. W. U.
Exocœtus bahiensis *Rans.* Flying Fish. P. W.

Exocœtus Roberti *M. & T.* Flying Fish. W.
Exocœtus Rondeletii *C. & V.* Flying Fish. E. W.
Cypselurus furcatus (*Mitch.*) *Weinl.* Flying Fish. P. W. U.
Fundulus Bermudæ *Gthr.* Pond Mullet. B.
Fundulus rhizophoræ *Goode*, (new species) 4. B.
Synodus lacerta *C. & V.* Snake Fish. E.
Synodus fœtens (*L.*) *Gill.* Snake Fish. U.
Trachinocephalus myops (*Schn.*) *Gill.* Snake Fish. P. U.
Albula conorhynchus *Schn.* Bone Fish. P. E. W. U.
Megalops thrissoides (*Schn.*) *Gthr.* Tarpum. W. U.
Sardinella anchovia *Val.* Anchovy. W.
Harengula macrophthalma (*Rans.*) *Goode.* Pilchard. W.
Opisthonema thrissa (*L.*) *Gill.* Herring. W. U.
Engraulis chœrostomus *Goode.* Hog Mouth Fry. B.
Carassius auratus (*L.*) *Blkr.* Gold Fish.

Order, *Apodes.*

Anguilla rostrata (*Les.*) DeKay. Pond Eel. P. U.
Gymnothorax moringa (*Cuv.*) *Goode.* Speckled Maray. E. W.
Gymnothorax punctatus (*Cast.*) *Goode.* Small Yellow Spotted Maray. P.
Thyrsoidea maculipinnis *Kaup.* Green Maray. W.
Muræna Sanctæ-Helenæ, *Gthr.* E.
Echidna catenata (*Bloch*) *Blkr.* W.
Ophisurus longus *Poey.* Sand Eel. W.
Ophichthys triserialis (*Kaup.*) *Gthr.* Spotted Sand Eel. P. W.
Leptocephalus (species undetermined).

Sub-class, GANOIDEA.

Order, *Glaniostomi.*

Acipenser, sp. Sturgeon.

Sub-class, ELASMOBRANCHII.

Order, *Raiæ.*

Ætobatis narinari (*Euphr.*) *M. & H.* Whip Ray. P. W. U.

Order, *Squali.*

Isuropsis, sp. Mackerel Shark.
Sphyrna zygæna (*L.*) *M. & H.* Hammer-Head Shark. P. E. W. U.
Eulamia obscura (*Les.*) *Gill.* Shark. U.
Mustelus canis (*Mitch.*) *DeKay.* Nurse Shark. U.
Ginglymostoma cirratum (*Gmel.*) *M. & H.* W. U.
Curious form in collection of J. M. Jones, genus and species undetermined.

Class, LEPTOCARDII.

Order, *Cirrostomi.*

Branchiostoma lubricum *Costa.* P. E. W. U.

DESCRIPTIONS OF NEW SPECIES.

1. *Julis nitidissima*, sp. nov.

This species agrees in many particulars with that described by Dr. Gunther under the name *Julis nitida*, from Jamaican specimens in the British Museum.*. There are, however, various diagnostic characters which it seems desirable to express in the form of a description, at the same time designating the Bermuda fish by a distinct specific name which, by its similarity to that of the species which it so much resembles, will indicate my suspicion that, upon comparison of the specimens, the two species may prove to be identical.

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* Catalogue of Fishes in the British Museum, vol. iv, p. 190, 1862.

The fish is quite small, rarely exceeding three inches in length, and is very abundant among the outer reefs, swimming among the Gorgonias and Plexauras, six or eight fathoms below the surface, a very conspicuous object by reason of its brilliant yellow colors. It is extremely shy and it was only after repeated trials that I succeeded in capturing a single specimen, which took a small hook baited for chubs.

The diagnostic characters which separate *Julis nitida* from *Julis nitidissima* appear to consist in (1) the relative proportions of head and body, (2) the relative proportions of pectorals and ventral fins, (3) the number of rows of scales below lateral line, and (4) in the coloration. The latter character is, however, of minor importance, it being quite possible that a faded museum specimen of the fish before me might have assumed the colors described by Dr. Günther.

The specimen described is small, though apparently adult, its total length being about three and one-half inches (m. 0·103). The body is much compressed, its greatest width (m. 0·009) being about three-eighths of its greatest height (m. 0·023), which is contained in the total length about four and one half times. Length of head (m. 0·025) contained in total length four and one half times (in fresh specimen three and three-quarters, it having been contracted by preservation in spirits). No posterior canine teeth. Length of snout (m. 0·008) equal to length of operculum (m. 0·008) and to four-fifths of greatest width of head (m. 0·01). Width of interorbital area (m. 0·007) somewhat less. Orbit circular, its diameter (m. 0·005) equal to greatest height of dorsal.

Dorsal inserted slightly in advance of origin of ventral at a distance (m. 0·03) equal to three times the greatest width of the head, length of base (m. 0·027) slightly greater than length of head. Length of first dorsal spine (m. 0·004) half the length of snout; greatest height of spinous dorsal (m. 0·005) equal to diameter of orbit. Greatest height of soft dorsal (m. 0·008) double that of first dorsal spine.

Distance of anal from snout (m. 0·052) twice the length of head, which is about equal to length of anal base (m. 0·024). First anal spine (m. 0·003) half the length of second anal spine (m. 0·007) and one-third the length of longest ray (m. 0·01).

Caudal lobes slightly produced, their length (m. 0·016) two-thirds that of the head and twice that of the snout. Least height of tail (m. 0·012) equal to length of ventrals.

Pectoral inserted at a distance from the snout (m. 0·028) equal to the length of the base of the dorsal, its length (m. 0·021) slightly less than the greatest height of the body.

Ventrals inserted at a distance from the snout (m. 0·031) a trifle greater than the dorsal. Length (m. 0·012) three-sevenths of that of the pectorals, not two-thirds as in *Julis nitida*—the most important of the diagnostic characters.

Radial formula, D. viii, 13. A. ii, 11.

Number of scales in lateral line, 26; in transverse line, 2:9.

Coloration:—Top of head and back brilliant sulphur-yellow; this color, above the pectorals, extending to middle of row of scales beneath lateral line, also present upon cheeks, opercles, and lips, and to ventral fins. A semicircular spot of the same occupying the major part of the caudal fin, extending posteriorly quite to the margin. Throat, belly and sides of tail white with a rich, deep roseate tinge. A band of maroon, as wide as the eye, crossing the snout passes back through the eye nearly to the tip of the opercular flap. A series of six broad irregular blotches of bottle green, somewhat quadrate in outline, each covering about the width of four transvere rows of scales, extends from the opercle, above the pectorals and across the downward curve of the lateral line to the base of the caudal. The posterior blotch is prolonged upon the outer rays of the caudal to the tips forming a crescent shaped figure. Dorsal fin at margin transparent, white, at the base yellow, the intermediate space brownish green, deeper in shade anteriorly, and between the second and fifth ray, forming a blotch, similar to that indicated in the description of *Julis nitida*. Pectorals transparent. Anal rose color with yellow transparent margin. Ventrals yellow. Caudal, as hitherto described, yellow with exterior lobes brownish green.

2. *Belone Jonesii*, sp. nov.

The total length of the specimen selected as a type of the species is eighteen inches (m. 0·60).

The body is slightly compressed, its greatest height, above the ventrals (m. 0·03) one-twentieth of total length, its greatest width (m. 0·022) about one twenty-eighth of the same. Free portion of tail somewhat depressed, quadrate, its height (m. 0·01) one-third of greatest height of body. Caudal carinæ moderate.

Length of head (m. 0·196) contained about three and two-fifths times in total length, and about three and one-fourth of length without caudal. Upper surface of head somewhat depressed, striated, with a broad shallow median groove, which expands posteriorly into a wide, somewhat depressed triangular area. Superciliary region sharply striated.

Length of snout (m. 0·12) equal to length of maxillary (m. 0·12), contained five times in total length, and containing post-orbital length of head (m. 0·04) thrice. Length of mandible (m. 0·14) slightly less than distance from snout to nape (m.

0·157) and ten times the vertical diameter of the eyes (m. 0·014). Lower jaw projects four millimeters beyond the tip of upper jaw. Horizontal diameter of eye (m. 0·019) equal to width of interorbital area (m. 0·019) and to length of operculum (m. 0·019) and about one-eighth of length of head.

Teeth large, sharp, not very close. Maxillary teeth about sixty, the largest three millimeters in length; mandibular teeth about sixty, the largest two millimeters in length. Vomerine teeth none.

Distances from insertion of dorsal to snout (m. 0·433) slightly greater than that of anal (m. 0·431). Length of dorsal (m. 0·097) equal to distance from insertion of dorsal to insertion of ventral. Greatest height of dorsal (m. 0·026) equal to greatest width of head (m. 0·025).

Anterior rays longest, their length (m. 0·03) one-tenth of distance from ventral to snout. Length of last ray (m. 0·013) about one-third of that of anterior rays.

Length of anal (m. 0·085) less than that of dorsal. Posterior rays half the length (m. 0·007) of posterior dorsal ray. Anal fin terminating anteriorly to dorsal at a distance equal to length of first dorsal ray.

Ventrals inserted at distance from snout (m. 0·34) greater than half the length of body, and midway between anterior margin of orbit and base of median caudal rays. Length (m. 0·028) slightly exceeding greatest width of head.

Pectoral inserted at distance from snout (m. 0·191) equal to ten times width of interorbital space; its length (m. 0·045) slightly exceeding postorbital length of head.

Caudal forked, the length of inferior rays (m. 0·053) exceeding that of superior rays (m. 0·04) by about the length of median rays (m. 0 012).

Radial formula—D, 9 + 14 : A, 14 + 7 : C, 5 + 10 − 9 + 6 : P, 13 : V, 5.

Branchiostegals, 12.

Number of scales in lateral line (estimated), 380.

Coloration:—Above deep green, below silvery white, opercles and cheeks silvery white. Anterior rays of dorsal and pectoral fins, with caudal carinæ blackish.

I take great pleasure in giving to this species the name of my friend Mr. J. Matthew Jones, F.L.S., President of the Nova Scotian Institute of Natural Sciences, who has for two winters been associated with me in the study of the Bermudian fauna.

The "Hound Fish," as it is called in Bermuda, is a graceful, active species, attains the length of three feet or more. It frequents swift tide courses where it preys upon small fishes, particularly the schools of *Atherina* and *Engraulis*. It takes the hook well.

3. *Atherina Harringtonensis*, sp. nov.

The length of the specimen selected as type of the species is one and one-half inches (m. 0·055), the measurement being that of a specimen which has been in strong alcohol for four months. From the discrepancy between this measurement and a partial set of measurements taken from a fresh specimen of the same species I infer that the shrinkage in the length of the body has been quite considerable, probably from six to eight millimeters. The proportions given below are taken from the alcoholic specimen. In the study of fresh specimens allowance should be made for discrepancies caused by this shrinkage. The proportions of the head do not appear to have been changed by the alcohol.

The height of body (m. 0·07) is contained in length about eight times (8½ in fresh specimen), its width about twice in its height.

Length of head (m. 0·011) about equal to length of caudal peduncle (m. 0·01) and contained five times in total length (5¾ in fresh specimen).

Diameter of eye (m. 0·004) about one-third the length of head, the length of snout somewhat less than that of post-orbital portion of head, also equal to length of maxillary, and slightly greater than width of inter-orbital area (m. 0·0037). Greatest width of head (m. 0·006) about double the length of snout. Length of mandible (m. 0·005) about equal to that of post-orbital portion of head. Cleft of mouth quite oblique, maxillary extending to the vertical from anterior margin of orbit. Lower jaw slightly the longer; mouth very protractile; teeth small, inconspicuous.

Spinous dorsal inserted behind extremity of ventral, at a distance from snout (m. 0·03) greater here than half the length of body. Anal directly beneath dorsal, their lengths of base (m. 0·007) being equal. Greatest height of anal (m. 0·005) greater than that of dorsal (m. 0·003).

Length of ventral (m. 0·006) two-thirds that of pectoral (m. 0·009) which exceeds three-fourths that of head.

Radial formula:—D. VII, I, 10: A. I, 11.

Number of scales in lateral line about forty-five; in transverse line about six.

Coloration:—Greenish white, a narrow silvery band extending from gill-opening to tail, covering the third row (from above) of scales and the edges of the contiguous rows above and below.

The "Russ Fry" occurs in immense quantities in all the lagoons and protected bays of the Bermudas. The schools swim near the surface of the water and are preyed upon by all the carnivorous species. They are particularly abundant in the beautiful little lagoon called Harrington Sound.

4. *Fundulus rhizophoræ*, sp. nov.

The length of the specimen selected as type is six centimeters. Height of body at insertion of pectorals (m. 0·015) one-fourth of total length, at ventral (m. 0·009) about one seventh, at base of caudal (m. 0·0075) one-eighth.

Head much depressed, its length (m. 0·017) contained three and one-eighth in total. Snout broad, obtuse, depressed, its length (m. 0·006) slightly longer than orbital diameter and contained in length of head about three times. Inter-orbital area broad and flat, its width (m. 0·007) less than length of post-orbital portion of head (m. 0·009) and greater than length of operculum (m. 0·006). Diameter of orbit (m. 0·0045) half the length of post-orbital tract.

Origin of dorsal fin equidistant from tip of caudal and anterior margin of snout, and over the eighteenth scale of lateral line. Distance from snout (m. 0·018) three-tenths of total length; extreme height (m. 0·006) one-tenth, and length of base (m. 0·008) two-fifteenths.

First anal ray below third dorsal ray; length of base (m. 0·005) one-twelfth of total length. Extreme height (m. 0·011) double length of base, and nearly double the extreme height of dorsal.

Ventral inserted slightly in advance of middle of body (distance from snout. m. 0·029), its length (m. 0·007) equal to width of inter-orbital area.

Pectoral inserted at distance from snout (m. 0·02) equal to one-third of total length; length (m. 0·009) equal to post-orbital length of head.

Length of caudal (m. 0·01) equal to height of anal and about one-sixth of total.

Radial formula:—D. 12 : A. 11.

Number of scales in lateral line thirty-five; rows in transverse line twelve or thirteen.

Coloration:—Ground color light tawny yellow with about fifteen regular transverse bands of greenish brown, each about two scales in width, obscure anteriorly but distinct upon posterior half of body.

This little minnow occurs abundantly in Basden Pond, a brackish marshy body of water at the eastern end of the main island, among the arching roots of the mangrove (*Rhizophora mangle*). It is known as the "Pond Mullet," but may more appropriately be called the Mangrove Minnow. The specimens described are young males, not in breeding colors.

ART. XLI.—*History of Cavern Exploration in Devonshire, England;* by W. PENGELLY, F.R.S., F.G.S., President of the Geological Section of the British Association at Plymouth.

* * * * AMONG the local geological papers read [before the British Association] in 1841 [at the time of its only previous visit to Plymouth,] none appear to have attracted so much attention as those on Lithodomous Perforations, Raised Beaches, Submerged Forests, and Caverns (see Athenæum for 7th to 28th of August, 1841); and, as an effort to connect the present with the past, I have decided on taking up one of these threads, and devoting the remarks I have now to offer to the History of Cavern-Exploration in Devonsire. I am not unmindful that there were giants in those days; and no one can deplore more than I do our loss of Buckland and De la Beche, among many others; nor can I forget the enormous strides opinion has made since 1841, when, in this Section, Dr. Buckland "contended that human remains had never been found under such circumstances as to prove their contemporaneous existence with the hyænas and bears of the caverns," and added that "in Kent's Hole the Celtic knives * * * * were found in holes *dug by art*, and which had disturbed the floor of the cave and the bones below it" (Athenæum, 14th Aug., 1841, p. 626). This scepticism, however, did the good service of inducing cavern explorers to conduct their researches with an accuracy which should place their results, whatever they might prove to be, amongst the undoubted additions to human knowledge.

The principal caverns in South Devon occur in the limestone districts of Plymouth, Yealmpton, Brixham, Torquay, Buckfastleigh, and Chudleigh; but as those in the last two localities have yielded nothing of importance to the anthropologist or the paleontologist, they will not be further noticed on this occasion. In dealing with the others it seems most simple to follow mainly the order of chronology; that is to say, to commence with the cavern which first caught scientific attention, and, having finished all that the time at my disposal will allow me to say about it, but not before, to proceed to the next, in the order thus defined; and so on through the series.

Oreston Caverns.—When Mr. Whidbey engaged to superintend the construction of the Plymouth Breakwater, Sir Joseph Banks, President of the Royal Society, requested him to examine narrowly any caverns he might meet with in the limestone-rock to be qarried a Oreston, near the mouth of the river Plym, not more than two miles from the room in which we are assembled, and have the bones or any other fossil remains that were met with carefully preserved (see Phil. Trans., 1817, pp.

176–182). This request was cheerfully complied with, and Mr. Whidbey had the pleasure of discovering bone-caves in November, 1816, November, 1820, August and November, 1822, and of sending the remains found in them to the Royal Society.

It is, perhaps, worthy of remark that, though cavern-researches received a great impulse from the discoveries in Kirkdale, Yorkshire, and especially from Dr. Buckland's well-known and graphic descriptions of them, such researches had originated many years before. The request by Sir Joseph Banks was made at least as early as 1812 (see Trans. Devon. Assoc., v, pp. 252, 253), and a paper on the Oreston discoveries was read to the Royal Society in February, 1817, whereas the Kirkdale Cavern was not discovered until 1821. British cave-hunting appears to have been a science of Devonshire birth.

The Oreston Caverns soon attracted a considerable number of able observers; they were visited in 1822 by Dr. Buckland and Mr. Warburton; and in a comparatively short time became the theme of a somewhat voluminous literature. Nothing of importance, however, seems to have been met with from 1822 until 1858, when another cavern, containing a large number of bones, was broken into. Unfortunately, there was no one at hand to superintend the exhumation of the specimens; the work was left entirely to the common workmen, and was badly done; many of the remains were dispersed beyond recovery; the matrix in which they were buried was never adequately examined; and we are utterly ignorant, and must for ever remain so, as to whether they did or did not contain indications of human existence. I visited the spot from time to time, and bought up everything to be met with; but other scientific work in another part of the county occupied me too closely to allow more than an occasional visit. The greater part of the specimens I secured were lodged in the British Museum, where they seem to have been forgotten, while a few remain in my private collection.

Some difference of opinion has existed respecting the character of the successive caverns, and much mystery has been imported into the question of the introduction of their contents. Mr. Whidbey, it is said, "saw no possibility of the cavern of 1816 having had any external communication through the rock in which it was inclosed" (Phil. Trans., 1817, pp. 176–182); but Dr. Buckland was of opinion that they were all at first fissures open at the top, and "that the openings had been long filled up with rubbish, mud, stalactite, or fragments of rock cemented, as sometimes happens, into a breccia as solid as the original rock, and overgrown with grass" (Phil. Trans., 1822, pp. 171–240).

The conclusion I arrived at, after studying so much of the roof of the cavern of 1858 as remained intact, was that Dr. Buckland's opinion was fully borne out by the facts; that, in short, the Oreston Caverns were *Fissure Caverns*, not *Tunnel Caverns.*

The cavern of 1858 was an almost vertical fissure, extending a length of about ninty feet from N.N.E. to S.S.W. It commenced at about eight feet below the surface of the plateau, continued thence to the base of the cliff, but how much farther was not known, and its ascertained height was about fifty-two feet. It was two feet wide at top, whence it gradually widened to ten feet at bottom. The roof, judging from that part which had not been destroyed, was a mass of limestone-breccia, made up of large angular fragments cemented with carbonate of lime, and requiring to be blasted as much as ordinary limestone. The cavern was completely filled with deposits of various kinds.

The uppermost eight feet consisted of loose angular pieces of limestone, none of which exceeded ten pounds in weight, mixed with a comparatively small amount of such sand as is common in dolomitic limestone districts, but without a trace of stalagmite or fossil of any kind. The thirty-two feet next below were occupied with similar materials, with the addition of a considerable quantity of tough, dark, unctuous clay. Between this mass and the outer wall of the cavern was a nearly vertical plate of stalagmite, usually about two feet thick, and containing, at by no means wide intervals, firmly cemented masses of breccia identical in composition with the adjacent bed just mentioned. The bones the cavern yielded were all found within these thirty-two feet; and were met with equally in the loose and the coherent breccia, as well as in the stalagmite. A somewhat considerable number of ellipsoidal balls of clay, from 1·5 to 2·5 inches in greatest diameter, occurred in the clay of this bone-bed, but not elsewhere. Still lower was a mass of dark, tough, unctuous clay, containing a very few, small, angular stones, but otherwise perfectly homogeneous, and known to be twelve feet deep, but how much more was undetermined.

The osseous remains found at Oreston prior to 1858 have been described by Sir E. Home, Mr. Clift, Dr. Buckland, Professor Owen, Mr. Busk, and others. The animals represented were *Ursus priscus*, *U. spelæus*, weasel (?), wolf, fox, cave hyæna, cave lion, *Rhinoceros leptorhinus*, *Equus fossilis*, *E. plicidens*, *Asinus fossilis*, *Bison minor*, *Bos longifrons*, and, according to the late Mr. Bellamy, mammoth and hippopotamus (see Nat. Hist. of S. Devon, 1839, p. 82). With regard to hippopotamus, I can only say that I have never met with satisfactory evidence of its occurrence in Devonshire; but the mammoth was certainly found at Oreston in 1858; and, unless I am greatly in error, remains of *Rhinoceros tichorhinus* were also met with there, and lodged by me in the British Museum. It may be added that the skull and other relics of a hog were exhumed on that occasion, and now belong to my collection. There was nothing to suggest that the cavern had been the home of the hyæna; and whilst I fully accept Dr. Buckland's opinion that animals had fallen into the open fissures and there perished, and that the remains had subsequently been washed thence into the lower vaultings ("Reliq. Dil.," 2d ed., 1834, p. 78), I venture to add that some of the animals may have retired thither to die; a few may have been dragged or pursued there by beasts of prey; whilst rains, such as are not quite unknown in Devonshire in the present day, probably washed in some of the bones of such as died near at hand on the adjacent plateau. Nothing appears to have been met with suggestive of human visits.

Kent's Hole.—About a mile due east from Torquay harbor and half a mile north from Torbay there is a small wooded limestone hill, the eastern side of which is, for the uppermost thirty feet, a vertical cliff, having at its base, and fifty-four feet apart, two apertures leading into one and the same vast cavity in the interior of the hill, known as Kent's Hole or Cavern. These openings are about 200 feet above mean sea-level, and from them the hill slopes rapidly to the valley at its foot, at a level of from sixty to seventy feet below.

There seems to be neither record nor tradition of the discovery of the cavern. Richardson, in the 8th edition of "A Tour through the Island of Great Britain," published in 1778, speaks of it as "perhaps the greatest natural curiosity" in the county. Its name occurs on a map dated 1769; it is mentioned in a lease 1659; visitors cut their names and dates on the stalagmite from 1571 down to the present century; judging from numerous objects found on the floor, it was visited by man through mediæval back to pre-Roman times; and, unless the facts exhumed by explorers have been misinterpreted, it was a human home during the era of the mammoth and his contemporaries.

In 1824 Mr. Northmore, of Cleve, near Exeter, was led to make a few diggings in the cavern, and was the first to find fossil bones there. He was soon followed by Mr. (now Sir) W. C. Trevelyan, who not only found bones, but had a plate of them engraved. In 1825, the Rev. J. MacEnery, an Irish Roman Catholic priest residing in the family of Mr. Cary, of Tor Abby, Torquay, first visited the cavern, when he, too, found teeth and bones, of which he published a plate. Soon after, he made another visit, accompanied by Dr. Buckland, when he had the good fortune to discover a flint implement; the first instance, he tells us, of such a relic being noticed in any cavern (see Trans. Devon. Assoc., iii, p. 441). Before the close of 1825, he commenced a series of more or less systematic diggings, and continued them until, and perhaps after, the summer of 1829 (ibid., p. 295). Preparations appear to have been made to publish the results of his labors; a prospectus was issued, numerous plates were lithographed, it was generally believed that the MS. was almost ready, and the only thing needed was a list of subscribers sufficient to justify publication, when, alas! on February 18, 1841, before the printer had received any "copy," before even the world of science had accepted his anthropological discoveries, before the value of his labors was known to more than a very few, Mr. MacEnery died at Torquay.

After his decease his MS. could not be discovered, and its loss was duly deplored. Nevertheless, it was found after several years, and, having undergone varieties of fortune, became the property of Mr. Vivian, of Torquay, who, having published portions of it in 1859, presented it in 1867 to the Torquay Natural History Society, whose property it still remains. In 1869 I had the pleasure of printing the whole, in the Transactions of the Devonshire Association.

Whilst Mr. MacEnery was conducting his researches, a few independent diggings, on a less extensive scale, were taken by other gentlemen. The principal of these was Mr. Godwin-Austen, the well-known geologist, whose papers fully bore out all that MacEnery had stated. (See Trans. Geol. Soc. Lond., 2d series, vi, 446). In 1846, a sub-committee of the Torquay Natural History Society undertook the careful exploration of very small parts of the cavern, and their report was entirely confirmatory of the statements of their predecessor—that undoubted flint implements did occur, mixed with the remains of extinct mammals, in the cave-earth, beneath a thick floor of stalagmite. The sceptical position of the authorities in geological science remained unaffected, however, until 1858, when the discovery and systematic exploration of a comparatively small virgin cavern on Windmill Hill, at Brixham, led to a sudden and complete revolution; for it was seen that whatever were the facts elsewhere, there had undoubtedly been found at Brixham flint implements commingled with remains of the mammoth and his companions, and in such a way as to render it impossible to doubt that man occupied Devonshire before the extinction of the cave mammals.

Under the feeling that the statements made by MacEnery and his followers respecting Kent's Hole were perhaps, after all, to be accepted as verities, the British Association, in 1864, appointed a committee to make a complete, systematic, and accurate exploration of the cavern, in which it was known that very extensive portions remained entirely intact. This committee commenced its labors on March 28, 1865; it has been re-appointed, year after year, with sufficient grants of money, up to the present time; the work has gone on continuously throughout the entire thirteen years; and the result has been, not only a complete confirmation of Mr. MacEnery's statements, but the discovery of far older deposits than he suspected—deposits implying great changes of, at least, local geographical conditions; changes in the fauna of the district; and yielding evidence of men more ancient and far ruder than even those who made the oldest flint tools found in Kent's Hole prior to the appointment of the committee.

The cavern consists of a series of chambers and passages, which resolve themselves into two main *divisions*, extending from nearly north to south in parallel lines, but passing into each other near their extremities, and throwing off branches, occasionally of considerable size.

The successive deposits, in descending order, were:—

1st, or uppermost. Fragments and blocks of limestone from an ounce to upwards of 100 tons weight each, which had fallen from the roof from time to time, and were, in some instances, cemented with carbonate of lime.

2d. Beneath and between these blocks lay a dark-colored mud or mould, consisting largely of decayed leaves and other vegetable matter. It was from three to twelve inches thick, and known as the *black mould*. This occupied the entire eastern division, with the exception of a small chamber in its south-western end only, but was not found in the other, the remoter, parts of the cavern.

3d. Under this was a stalagmitic floor, commonly of granular texture, and frequently laminated, from less than an inch to fully five feet in thickness, and termed the *granular stalagmite*.

4th. An almost black layer, about four inches thick, composed mainly of small fragments of charred wood, and distinguished as the *black band*, occupied an area of about 100 square feet, immediately under the granular stalagmite, and, at the nearest point, not more than twenty-two feet from one of the entrances to the cavern. Nothing of the kind has occurred elsewhere.

5th. Immediately under the granular stalagmite and the black band lay a light red clay, containing usually about fifty per cent of small angular fragments of limestone, and somewhat numerous blocks of the same rock as large as those lying on the black mould. In this deposit, known as the *cave-earth*, many of the stones and bones were, at all depths, invested with thin stalagmitic films. The cave-earth was of unknown depth near the entrances, where its base had never been reached; but in the remoter parts of the cavern it did not usually exceed a foot, and in a few localities it "thinned out" entirely.

6th. Beneath the cave-earth there was usually found a floor of stalagmite having a crystalline texture, and termed on that account the *crystalline stalagmite.* It was commonly thicker than the granular floor, and in one instance but little short of twelve feet.

7th. Below the whole occurred, so far as is at present known, the oldest of the cavern deposits. It was composed of subangular and rounded pieces of dark-red grit, embedded in a sandy paste of the same color. Small angular fragments of limestone, and investing films of stalagmite, both prevalent in the cave-earth, were extremely rare. Large blocks of limestone were occasionally met with; and the deposit, to which the name of *breccia* was given, was of a depth exceeding that to which the exploration has yet been carried.

Except in a very few small branches, the bottom of the cavern has nowhere been reached. In the cases in which there was no cave-earth, the granular stalagmite rested immediately on the crystalline; and where the crystalline stalagmite was not present the cave-earth and breccia were in direct contact. Large isolated masses of the crystalline stalagmite, as well as concreted lumps of the breccia, were occasionally met with in the cave-earth, thus showing that the older deposits had, in portions of the cavern, been partially broken up, dislodged, and re-deposited. No instance was met with of the incorporation in a lower bed of fragments derived from an upper one. In short, wherever all the deposits were found in one and the same vertical section, the order of superposition was clear and invariable; and elsewhere the succession, though defective, was never transgressed.

Excepting the overlying blocks of limestone, of course, all the deposits contained remains of animals, which, however, were not abundant in the stalagmites.

The black mould, the uppermost bed, yielded teeth and bones of man, dog, fox, badger, brown bear, *Bos longifrons*, roedeer, sheep, goat, pig, hare, rabbit and seal—species still existing, and almost all of them in Devonshire. This has been called the *Ovine* bed, the remains of sheep being restricted to it. In it were also found numerous flint flakes and "strike-lights," stone spindle-whorls, fragments of curvilineal pieces of slate, amber beads, bone tools, including awls, chisels and combs; bronze articles, such as rings, a fibula, a spoon, a spear-head, a socketed celt, and a pin; pieces of smelted copper, and a great number and variety of potsherds, including fragments of Samian ware.

The granular stalagmite, black band, and cave-earth, taken together as belonging to one and the same biological period, may be termed the *Hyænine* beds, the cave hyæna being their most prevalent species, and found in them alone. So far as they have been identified, the remains belong to the cave hyæna, *Equus caballus*, *Rhinoceros tichorhinus*, gigantic Irish deer, *Bos primigenius*, *Bison priscus*, red deer, mammoth, badger, cave bear, grizzly bear, brown bear, cave lion, wolf, fox, reindeer, beaver, glutton, *Machairodus latidens*, and man—the last being a part of a jaw with teeth, in the granular stalagmite. In the same beds were found unpolished *ovate* and *lanceolate* implements made from *flakes*, not *nodules*, of flint and chert; flint flakes, chips, and "cores;" "whetstones," a "hammer-stone," "dead" shells of *Pecten*, bits of charcoal, and bone tools, including a needle or bodkin having a well-formed eye, a pin, an awl, three harpoons, and a perforated tooth of badger. The artificial objects, of both bone and stone, were found at all depths in each of the hyænine beds, but were much more numerous below the stalagmite than in it.

The relics found in the crystalline stalagmite and the breccia, in some places extremely abundant, were almost exclusively those of bear, the only exceptions being a very few remains of cave line and fox. Hence these have been termed the *Ursine* beds. It will be remembered that teeth and bones of bear were also met with in both the hyænine and the ovine beds; and it should be understood that this biological classification is intended to apply to Kent's Cavern only. The ursine deposits, or rather the breccia, the lowest of them, also yielded evidences of human existence; but they were exclusively tools made from *nodules*, not *flakes*, of flint and chert.

Ansty's-Cove Cavern.—About three furlongs from Kent's Hole toward N.N.E., near the top of the lofty cliff forming the northern boundary of the beautiful Ansty's Cove, Torquay, there is a cavern where, simultaneously with those in Kent's Cavern, Mr. MacEnery conducted some researches, of which he has left a brief account (see Trans. Devon. Assoc., vi, pp. 61–69). I have visited it several times, but it seems to be frequently kept under lock and key, as a tool and powder-house, by the workmen in a neighboring quarry. It is a simple gallery, and, according to Mr. MacEnery, sixty-three feet long, from three to nine feet high, and from three to six feet broad. Beneath some angular stones he found a stalagmitic floor fourteen inches thick, and in the deposit below remains of deer, horse, bear, fox, hyæna (?), coprolites, a few marine and land shells, one white flint tool with fragments of others, a Roman coin, and potsherds.

In a letter to Sir W. C. Trevelyan, dated December 16th, 1825, Dr. Buckland states that Mr. MacEnery had found in this cave "bones of all sorts of beasts, and also flint knives and Roman coins; in short, an open-mouthed cave, which has been inhabited by animals of all kinds, quadruped and biped, in all successive generations, and who have all deposited their exuviæ one upon another" (ibid., p. 69).

Yealm-Bridge Cavern.—About the year 1832 the workmen broke into a bone-cavern in Yealm-Bridge Quarry, about one mile from the village of Yealmpton, and eight miles E.S.E. from Plymouth; and through their operations it was so nearly destroyed that but a small arm of it remained in 1835, when it was visited by Mr. J. C. Bellamy, who at once wrote an account of it, from which it appears that, so far as he could learn, the cavern was about thirty feet below the original limestone surface, and was filled to from one foot to six feet of the roof (see "Nat. Hist. S. Devon.," 1839, pp. 86–105). In the same year, but subsequently, it was examined by Capt. (afterwards Col.) Mudge, who states that there were originally three openings into the cave, each about twelve feet above the river Yealm; that the deposits were, in descending order:—

1. Loam with bones and stones	3·5	feet.
2. Stiff whitish clay	2·5	"
3. Sand	6·0	"
4. Red clay	3·5	"
5. Argillaceous sand	6 to 18·0	"

and that, where they did not reach the roof, the deposits were covered with stalagmite.

On the authority of Mr. Clift and Prof. Owen, Capt. Mudge mentions relics of elephant, rhinoceros, horse, ox, sheep, hyæna, dog, wolf, fox, bear, hare and water-vole. The bones, and especially the teeth, of the hyæna exceeded in number those of all the other animals, though remains of horse and ox were very abundant. Mr. Bellamy, whilst also mentioning all the foregoing forms, with the exception of dog only, adds deer, pig, glutton, weasel and mouse. He also speaks of the abundance of bones and teeth of hyæna, but seems to regard the fox as being almost as fully represented; and next in order he places horse, deer, sheep, and rabbit or hare; whilst the relics of elephant, wolf, bear, pig and glutton are spoken of as very rare. The bones, he says, were found in the uppermost bed only. They were frequently mere fragments and splinters, some being undoubtedly gnawed, and all had become very adherent through loss of their animal matter. Those of cylindrical form were without their extremities; there was no approach to anatomical juxtaposition; and the remains belonged to individuals of all ages. Reliquiæ of carnivorous animals greatly exceeded those of the herbivora, and teeth were very abundant. Coprolites occurred at some depth below the stalagmite, in the upper bed, which also contained granitic and trappean pebbles, and lumps of breccia made up of fragments of rock, bones, pebbles, and stalagmite. The bones found prior to 1835 had been removed as rubbish, and some good specimens were recovered from materials employed in making a pathway. Nothing indicating the presence of man appears to have been found.

The Ash-Hole.—On the southern shore of Torbay, midway between the town of Brixham and Berry Head, and about half a mile from each, there is a cavern known as the *Ash-Hole.* It was partially explored, probably about, or soon after, the time Mr. MacEnery was engaged in Kent's Hole, by the late Rev. H. F. Lyte, who, unfortunately, does not appear to have left any account of the results. The earliest mention of this cavern I have been able to find is a very brief one in Bellamy's "Natural History of South Devon," published in 1839 (p. 14). During the Plymouth Meeting in 1841, Mr. George Bartlett, a native of Brixham, who assisted Mr. Lyte, described to this Section the objects of interest the Ash-Hole had yielded (see Report Brit. Assoc. 1851, Trans. Sections, p. 61). So far as was then known the cave was thirty yards long and six yards broad. Below a recent accumulation, four feet deep, of loam and earth, with land and marine shells, bones of the domestic fowl and of man, pottery, and various implements, lay a true cave-earth, abounding in the remains of elephant. Prof. Owen, who identified, from this lower bed, relics of badger, polecat, stoat, water-vole, rabbit and reindeer, remarks, that for the first good evidence of the reindeer in this island he had been indebted to Mr. Bartlett, who stated that the remains were found in this cavern (see "Brit. Foss. Mam." 1846, pp. 109–110, 113–114, 116, 204, 212, 479–480). I have made numerous visits to the spot, which, when Mr. Lyte began his diggings, must have been a shaft-like fissure, accessible from the top only. A lateral opening, however, has been quarried into it: there is a narrow tunnel extending westward, in which the deposit is covered with a thick sheet of stalagmite, and where one is tempted to believe that a few weeks' labor might be well invested.

(To be continued.)

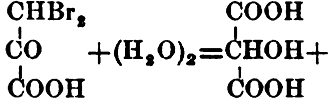
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a modification of Dumas's Vapor-density method.*—**Habermann** has suggested a modification in the method proposed by Dumas for estimating vapor-densities, which consists in applying to this method the improvement in Gay Lussac's method suggested by Hofmann, of making the experiment under reduced pressure. For this purpose the neck of the balloon, which is made thick at the end, is connected, first with a double-bulb tube which serves as a receiver, and then through this with a Bunsen pump furnished with a manometer to indicate the residual tension. After the substance—about one gram—is introduced into the balloon, and this is lowered into the bath and connected to the pump, an exhaustion of 500 or 600 millimeters is effected, the cock to the pump is closed and the heating is proceeded with, a temperature higher than that at which the substance boils, never being required. After this point has been for a short time reached, the exhaustion is returned to its former point, the neck of the balloon is sealed by the blowpipe, and the thermometer, barometer and manometer read. The calculation is made as usual, only using instead of the barometric height at the time of sealing, the difference between this and that of the manometer, in the calculation for the reduction of volume.—*Liebig's Ann.*, clxxxvii, 341, June, 1877. G. F. B.

2. *On the action of Phosphoric chloride on Tungstic oxide.*—**Teclu** has proved that the sole products of the action of tungstic oxide upon phosphoric chloride are phosphoryl chloride and tungstic chloride (tungsten hexachloride). Equivalent weights—three molecules PCl_5 and one of WO_3—of the pure substances were sealed in glass tubes, well shaken, and heated in a paraffin bath to 200° C., for six or eight hours. On cooling, brilliant metallic steel-blue crystals appeared in the tubes, which swelled up in the air by attracting moisture and were rapidly decomposed. They were slightly soluble in absolute alcohol, more so in ether, and easily soluble in carbon disulphide. The contents of a tube was submitted to distillation, and the distillate proved to be phosphoryl chloride. The residue was heated to 120° and a current of dry carbon dioxide gas was passed over it. The last traces of $PO\ Cl_3$ were thus removed and the crystals obtained pure. For quantitative analysis, a weighed quantity was heated to 100° in a sealed tube with water and nitric acid, and the chlorine determined as usual. The result showed the crystals to be tungsten hexachloride. By slow cooling of the phosphoryl chloride solution, in the tubes where they are formed, the crystals may be obtained of considerable size. The crystals are isometric, and fuse at 189°. The reaction is given by the equation:—$WO_3+(PCl_5)_3=WCl_6+(POCl_3)_3$.—*Liebig's Ann.*, clxxxvii, 255, June, 1877. G. F. B.

3. *On the production of Tartronic from Pyruvic acid.*—GRIMAUX, in attempting to replace the two atoms of bromine in dibrom-pyruvic acid, by one of oxygen, by acting upon the acid by barium hydrate, has produced not $C_3H_2O_4$, the acid wished, but $C_3H_4O_5$, tartronic acid. The dibrom-pyruvic acid was dissolved in two or three times its weight of water, and barium hydrate gradually added, the temperature being kept at 30° to 40°. A white precipitate soon formed, which, decomposed by sulphuric acid, yielded a crystallized acid, very soluble in water and alcohol, fusing about 142°, and yielding the above formula on analysis. The author thinks that the mesoxalic aldehyde-acid CHO—CO—COOH is first formed, but that this body being at the same time an aldehyde and an acetone, is oxidized on its aldehydic side and reduced on its acetonic. Hence it is hydrated and gives COOH—CHOH—COOH, which is tartronic acid. The reaction is



$$\begin{array}{l} CHBr_2 \\ | \\ CO \\ | \\ COOH \end{array} + (H_2O)_2 = \begin{array}{l} COOH \\ | \\ CHOH \\ | \\ COOH \end{array} + (HBr)_2,$$

analogous to the transformation of dichloracetone into lactic acid. —*Bull. Soc. Ch.*, II, xxvii, 440, May, 1877. G. F. B.

4. *On a Hexyl Chloral.*—PINNER has subjected to a more careful examination an oily body of high boiling point, first observed by him nearly two years ago in the distillation of crude butyl chloral. From a kilogram of this oil from the factory of Schering, he has prepared half a pound of the oil boiling between 212° and 220°, the rest being butyl chloral. Further fractioning gave him a portion boiling at 212°—214°, which gave on analysis the formula $C_6H_9Cl_3O$. It does not unite with water to form a hydrate and is decomposed by strong bases into a formate and chloride of the base and into $C_5H_8Cl_2$. It is oxidized by nitric acid and yields trichlorcapronic acid, $C_6H_9Cl_3O_2$. Reducing agents, such as zinc powder, reduce this acid to hexylenic acid $C_6H_{10}O_2$, which crystallizes from ether in brilliant white needles, fuses at 39°, is almost insoluble in water, and does not appear to be identical with any of the three known acids having the same empirical formula.—*Ber. Berl. Chem. Ges.*, x, 1052, June, 1877.

G. F. B.

5. *On the Conversion of Aurin into Rosaniline.*—DALE and SCHORLEMMER have discovered that red aurin or peonin, heated for several days to 150° with alcoholic, or to 200° with aqueous ammonia, loses its red color and gives a yellow solution, which contains a colorless crystalline base possessing all the properties of rosaniline, giving the well-known magnificent red color with acetic acid and a dark yellow solution with hydrochloric acid, which becomes red on dilution and gives a spectrum identical with that of rosaniline hydrochlorate. Conversion into Hofmann's violet, aniline green and aniline blue still farther confirmed this identity. The reaction is given as follows:—$C_{20}H_{14}O_3+(NH_3)_3=C_{20}H_{17}N_3+(H_2O)_3$. The authors regard aurin and

rosolic acid as identical.—*Ber. Berl. Chem. Ges.*, x, 1052, June, 1877.
G. F. B.

6. *On Hematin.*—Cazeneuve has prepared hematin and examined its properties. For its preparation, defibrinated blood was treated with twice its volume of commercial ether, allowed to stand twenty-four hours, the ether decanted from the clot, and this clot exhausted by the ether containing now two per cent of oxalic acid. The etherial solution, colored a brownish-red by the hematin, was exactly saturated by ether charged with ammonia gas, and the precipitated hematin was collected, washed with water, alcohol and ether and then dried. The product is pure hematin. In presence of alcohol and ether, it combines readily with hydrochloric, hydrobromic, and hydriodic acids, giving crystallized compounds. On analysis, it afforded 64·18 per cent of carbon, 5·67 hydrogen, 9·03 nitrogen, 8·74 iron and 12·38 of oxygen, corresponding to the formula $C_{68}H_{70}N_8Fe_2O_{10}$. Though it combines with alkalies, it yields no crystalline products. Its ammonia compound is stable at 100°. With lead, zinc, and aluminum hydrates, it gives greenish lakes. It does not disengage ammonia, when boiled with a concentrated solution of potash in alcohol for hours. Heated to 150° for two hours in a sealed tube with concentrated hydrochloric acid, the solution becomes remarkably dichroic; and the hematin splits into two substances (A) and (B). The first is obtained pure by the dialysis of the solution till it is no longer acid. It exists as suspended flocks, the liquid being precipitated completely by a single drop of ammonia, yielding a gelatinous mass containing 37·62 per cent of iron. Its spectrum is peculiar; in acid solutions, it consists of two strong absorption bands in the yellow and yellow-green, in alkaline solutions, it gives four bands, one in the red, one in the yellow-green, one in the blue and one in the violet. The other substance (B) is the part insoluble in hydrochloric acid. On washing it, dissolving it in soda and precipitating by acetic acid, it is purified. It contains only 2·08 per cent of iron, and its solution in acid alcohol gives a one-banded spectrum, in alkalies, a four-banded one.—*Bull. Soc. Ch.*, II, xxvii, 485, June, 1877.
G. F. B.

7. *On the Nature of what is commonly termed a "Vacuum;"* by G. Johnstone Stoney, Queen's University, Dublin, August 19, 1877.—The readers of Mr. Preston's paper in the August number of the Philosophical Magazine, "On the Nature of what is commonly termed a 'Vacuum,'" might perhaps suppose with him that the subject is one which had not been previously noticed, and conclude that we are as yet without an explanation of "Crookes's force," in which the vast multitude of the gaseous molecules that are present has been taken into account.

The subject is one which cannot, I should think, have been overlooked by any real student of the molecular theory of gases; and in particular your readers will find it thus treated in a paper that I presented ten years ago to the Royal Society (see Phil. Mag. [IV], vol. xxxvi, p. 141):—"It is therefore probable that there are not fewer than something like a unit-eighteen of molecules" [i. e. 1,000000,000000,000000] "in each cubic millimeter of a gas at ordinary temperatures and pressures. Hence we may see how entirely remote from a state of emptiness that which usually passes under the name of a vacuum-chamber really is. If there be a unit-eighteen of molecules in every cubic millimeter of the air about us, there will remain a unit-fifteen" [i. e. a thousand millions of millions] "in every cubic millimeter of the best vacuums of our ordinary air-pumps. The molecules are still closely packed, within about an eighth-meter of one another; i. e. there are about sixty of them in a wave-length of orange light." And in two papers published in last year's Philosophical Magazine [V], vol. i, pp. 177 and 305, I offered an explanation of the mechanical stresses within Crookes's radiometers based upon this very consideration: see in particular page 178, where the following words occur:—"I cannot refrain from observing here how entirely remote such a chamber" [viz. a Sprengel vacuum indicated by one-tenth of a millimeter of mercury] "is from being empty. It follows from what we know of the number of molecules in gases at ordinary pressures, that the number remaining in this so-called vacuum will be somewhere about a unit-fourteen, i. e. one hundred millions of millions, in every cubic millimeter." After which I quote, in proof of this assertion, the determinations of the mean interval at which the molecules of gases are spaced, by Professor Loschmidt in 1865, by myself in 1867, and by Sir William Thomson in 1870.

It is plain, however, that Mr. Preston has done good service by recalling attention to the immense number of the molecules, and the consequent shortness of the excursions of each molecule between its successive encounters with other molecules; since the subject was new to himself, and had been overlooked by some of the writers upon Crookes's radiometer.—*Phil. Mag.*, Sept. 1877, p. 222.

8. *Note on the Telephone;* by PAGET HIGGS.—In the present agitation concerning speaking or telephonic telegraphs, the following extract from M. Le Comte du Moncel's "Exposé des Applications de l'Electricité," edition of the year 1857, vol. iii, p. 110, may be interesting as pointing out how nearly the idea has been forestalled.

"*The Electric Transmission of Speech.*—I did not wish to bring forward in the chapter of the electric telegraph a fantastic conception of a certain M. Ch. B——, who believes that it will be possible to transmit speech electrically, because it might have been asked why I had classed among so many remarkable inventions an idea that, presented by the author as it is, is not more than a dream. However, to be faithful to the *rôle* that I have imposed upon myself of speaking of all the applications of electricity that have become known to me, I wish to quote here the information which the author has published on this subject.

'After the marvelous telegraphs which are able to reproduce at a distance writing of this or that individual, and designs more or less complicated, it seemed impossible, said M. B——, to advance further in the region of the marvellous. Nevertheless, essaying to do something more, I asked, for example, if speech itself would not be capable of transmission by electricity; in a word, if one would not be able to speak at Vienna and be heard at Paris. The thing is practicable. This is how: Sounds, it is known, are formed by vibrations and carried to the ear by these same vibrations, which are reproduced by the intermediate media.

'But the intensity of these vibrations diminishes very rapidly with the distance, from which it follows, even in the employment of speaking trumpets, tubes, ard of acoustical horns, the limits which cannot be surpassed are very restricted. *Imagine that one speaks near a mobile plate, flexible enough not to lose any of the vibrations produced by the voice, that this plate establishes and interrupts successively the communication with a battery. You would be able to have at a distance another plate which would execute at the same time the same vibration.*

'*It is true that the intensity of the sounds produced would be variable at the point of departure where the plate is vibrated by the voice, and constant at the point of arrival where it is vibrated by electricity.* But it is demonstrable that this would not alter the sounds.

'It is evident from the first that the sounds would reproduce themselves with the same pitch in the scale. The actual condition of acoustical science does not permit of saying, *à priori*, whether the same conditions would hold good for all syllables articulated by the human voice. The manner in which these syllables are produced is not yet sufficiently well known.

. . . .

'In any case it is impossible to demonstrate, in the present state of science, that the electric transmission of sounds is impossible. Every probability, on the contrary, is for the possibility. An electric battery, two vibrating plates, and a metallic wire will suffice.

. . . .

'It is certain that, at a time more or less distant, speech will be transmitted to a distance by electricity. I have commenced some experiments to that effect, they are delicate and require time and patience. But the approximations obtained point toward a favorable result.' "—*Nature*, of Aug. 30.

II. GEOLOGY AND MINERALOGY.

1. *Archæan of Canada.* (Letter from Mr. HENRY G. VENNOR, of the Geological Survey of Canada, to J. D. Dana, dated Buckingham, July 10th, 1877.)—I take the liberty of addressing this letter to you, on a subject in which I have for some years been particularly interested, viz: the stratigraphical position of the economic minerals in what we have hitherto called the Lower Laurentian system of rocks.

I may briefly give you the results arrived at, after now some ten years' work in Eastern Ontario and the adjoining portion of the Province of Quebec, namely, Pontiac and Ottawa counties. We find that there still exists a great *Azoic* formation, consisting of syenite and gneiss (?) without crystalline limestones. In this there are but little indications of stratification. Occasionally a limited surface presents an approach to an *obscure stratification*, but this does not appear to be due to the deposition of sediment. This rock forms the back-bone of Canada. On it there has been deposited a great series of gneisses, schists, slates, crystalline limestones and dolomites, which, although heretofore grouped with the former, is clearly distinct and unconformable. This second system contains *all of the economics* of any importance; none having been found in the old fundamental red gneiss system. All of these economics are in close proximity and have close relationship to each of the four or five great bands of crystalline limestone.

Eozoon Canadense belongs undoubtedly in the main to the highest band of crystalline limestone yet found, although this fossil may, and indeed has been sparingly found in some of the lower limestones. The celebrated Petite Nation locality for *Eozoon*, has now been proved to be on this highest band of limestone, and in fact in *the most recent portion of my second system;* the zone of limestone in which this fossil occurs is especially characterized by an abundance of serpentine and chrysotile. It is further traversed by veins filled with baryta and galena, and these also extend up through the Potsdam and Calciferous formations, but do not enter far into the crystalline rocks, both minerals rapidly giving out as we descend into these older rocks; while the fissures themselves narrow to threads and bifurcate. This fact has been proved by a close and careful investigation in Rossie, N. Y., and Lansdowne, Loughbon, Bedford, Madoc, and Tudor, in Canada.

Immediately beneath the *Eozoon* limestone the apatite-bearing belt of rocks come in with horizons of both hematitic and magnetic iron ores—chiefly the former; and immediately below these again a great belt of plumbago-bearing rock (extensively wrought for this mineral in Buckingham and Lochaber, Ottawa county), an important volume of crystalline limestone filled with rust-colored lumps and beds. This band of limestone is the second in descending order. A short distance beneath this last (some twenty or thirty chains), is an important and well-marked horizon of magnetic iron ore—occasionally with layers of hematite, in which occur a number of promising mines (e. g. the Baldwyn and Forsythe mines, Hull, P. Q.; the Christies' Lake and Silver Lake mines in South Sherbrooke, Lanark county, Ontario, etc.)

On a still lower horizon and close to the third belt of limestone, there is another iron ore horizon of coarsely crystalline magnetite with apatite intimately associated, which has now been identified and followed continuously for upwards of one hundred miles.

Lastly, in a still lower, fourth and last important volume of limestone, we find some large deposits of hematite iron ore (e. g. the Cowan mine in Dalhousie township, Lanark county), but these in so far as investigated, are superficial deposits, only penetrating some fifty or eighty feet into the limestone; but the particular layer in which they occur may be followed by its deep hematite red color throughout a great extent of country.

The order then thus given to the economic minerals, just mentioned, is, in ascending order, as follows:—1st, hematitic iron ore; 2d, magnetite and apatite (unimportant); 3d, magnetite and hematite (important); 4th, plumbago (very extensive); 5th, phosphate of lime, with iron ores (an important and extensively worked belt; and then 6th, *Eozoon Canadense* in abundance with serpentine, chrysotile and veins of baryta and galena.

You will thus observe that iron ore runs through the series, though most important in one horizon; that plumbago (with a great deal of pyrites cobaltiferous) is toward the upper portion; while the great body of apatite-bearing rock is at the very summit.

Having established this important sequence my thoughts at once flew back to the discoveries of phosphatic nodules and shells in the Lower Silurian rocks at the Allumettes Rapids (Geology of Canada, page 125), and in several places in the eastern townships and elsewhere. Is it not probable that the source of our mineral apatite is in the Lower Silurian rocks, whence it has penetrated into the upper portion of the *second division* of the Laurentian system? Or, may the *Eozoon* not have furnished a considerable portion of the supply? Possibly *Lingulæ* may have abounded along with the Eozoon, but if so their remains have been entirely obliterated by crystallization or other metamorphism. I think that the gap between the Lower Silurian and uppermost crystalline rocks of the Laurentian is considerably lessened by the results of our explorations, particularly as we can show that the same veins which cut the former, affect the latter, but do not reach the fundamental *Azoic* system, to which I must now (in my section) restrict the term Lower Laurentian. I cannot now enlarge, but I may simply state that I consider both the Huronian and Upper Laurentian of Sir W. E. Logan to belong rightly to my second division, which I must for the present call Upper Laurentian. Should an Upper Laurentian yet be found above and unconformable to *my series*, then I have been working on a middle series, to which the term Huronian might as well be applied as any other.

I have found Labradorite rocks clearly interstratified with several of my bands of limestone, and I fail entirely to discover Sir William's upper distinct system—yet I have been over the same ground.

The *Huronian and Hastings series of rocks* I believe to be simply an altered condition, on their westward extension, of the lower portion of my *second system;* and this alteration commences as this portion reaches Hastings county, where you will remember Hunt, Macfarlane and others likened them to the Huronian, while Sir William thought they more resembled some portions of the Devonian.

2. *The Geology of New Hampshire.* C. H. HITCHCOCK, State Geologist, J. H. HUNTINGTON, WARREN UPHAM, and G. W. HAWES, Assistants. Part II, Stratigraphical Geology. 684 pp. Royal 8vo, with many maps, plates, and sections. Concord, 1877. —This large volume consists mainly of chapters by Professor Hitchcock. The geology of the Coös and Essex Topographical district and of the west part of the Merrimac district, and some other brief sections are by Mr. J. H. Huntington.

The difficulties of the survey have been great on account of the extent of the surface covered by unbroken forests, and the disturbed crystalline condition of the rocks. But, through great labor, the distribution of the several kinds of metamorphic rocks has been to a large extent made out, and is carefully described in the Report. Professor Hitchcock has carried forward the work with energy and fidelity, and has presented not only his own views, but also, with fairness, as far as he has understood them, the views of others. As to the conclusions from the facts presented in the volume, Professor Hitchcock is aware that the writer differs from him in many points; and if in the remarks beyond some of these differences are mentioned it will be without the assumption on the writer's part that he is always right.

Professor Hitchcock refers the crystalline rocks of New Hampshire—taking his latest conclusions from the closing pages of the volume—to the following groups in ascending order:—Laurentian; Montalban (inferior to Huronian, and so named from the Latin for White Mountains); Lower and Upper Huronian; above these, Paleozoic with a query; Cambrian; the Coös group; the Calciferous mica schist; and above these, the Lower Helderberg. Besides, there are various areas of eruptive granite recognized, including those of the "Conway granite," "Albany granite," "Chocorua series," and others.

The *Laurentian* includes a porphyritic gneiss, Bethlehem gneiss, Lake Winnipiseogee gneiss; the *Montalban*, Concord granite, feldspathic mica schists, the associated gneisses, fibrolite schists; the *Upper Huronian*, hornblende schist, chlorite schist, greenstones, and other rocks; the *Coös*, staurolite slate, staurolitic mica schist, quartzyte; overlying the Coös, Calciferous mica schist, in which obscure crinoidal fragments have been found.

The age of these rocks, the Helderberg excluded, has been determined by Prof. Hitchcock mainly by lithological characteristics—a species of evidence not yet proved to be satisfactory. The writer is led by his observations among New England rocks to conclude that, so far as lithological distinctions go, all the metamorphic rocks of the White Mountains, with perhaps one or two exceptions, might belong to one of the ages in geology: (and that even one stratum may, after metamorphism, be, in its different parts, andalusite slate, mica schist, andalusitic mica schist, gneiss, porphyritic gneiss, granite). As to what age, or whether to one, or to more than one, the facts thus far collected afford no satisfactory basis, as the writer believes, for a decisive opinion. Further: observations in different parts of New England have convinced him that the granites, supposed by Professor Hitchcock to be eruptive, may be for the most part, if not in all cases, metamorphic; and this appears to be sustained by the facts, as to position and relation to the other rocks, connected with the granite of Mt. Willard (one of the areas made eruptive), as is pointed out beyond.

The account of the White Mountain region occupies 170 pages of the Report, and will attract especial attention. Following this comes a chapter on the geology of the Connecticut Valley, which also is of prominent importance in connection with New England geological investigations.

The chief facts of interest in the valley region is the occurrence at three places of limestone containing Lower Helderberg fossils—corals, crinoids, or brachiopods, associated with various metamorphic rocks. These places are in Littleton and North Lisbon, New Hampshire, and in Bernardston, Massachusetts. The limits of the Helderberg areas are laid down with some acknowledged doubts as to whether the group does not embrace also the "Coös group;" and there is room left for a query whether they should not include also what is called the "Lisbon group" (chlorite schist, chlorite rocks or greenstones, with some hydromica slate, etc.), and the "Lyman group." The section given on page 326 of the Littleton rocks represents a synclinal of slate (the uppermost bed), limestone, and quartzyte, with beds of the "Lisbon group" and "Lyman group" essentially *conformable* to the limestone. Plate XV (facing p. 385), contains another section of this region, showing the same conformability of the Lyman, Lisbon, and Helderberg groups. On pages 329 and 331, this conformability is again exhibited in sections, and also on plate XIII. Professor Hitchcock, however, calls the Lisbon and Lyman groups Huronian, a conclusion that is not suggested by the above-mentioned sections.

The relations of the Helderberg limestone of Bernardston to the associated micaceous, hornblendic and other rocks the writer has interpreted very differently from Professor Hitchcock, and he will give the results of new observations in another number of this Journal.

Some of the most interesting facts in the White Mountain region are those observed along the valley west of the Mount Washington range of peaks. This valley, at the Notch and south of it (here trending about north-and-south), has Mount Willard and Mount Willey on the west (the latter two miles south of the former), and Mount Webster on the east, opposite Mount Willey. The rocks of the west side in this part are, going southward, a light-colored well characterized granite ("Conway Granite"), the chief constituent of Mount Willard, in view above the Notch;

a hard siliceous granitoid gneiss, varying into true granite, forming the eastern foot of Mount Willard, to the east of the Mount Willard granite, in the Notch; then, continuing southward, but at first a little westward, andalusite slate, meeting the Mount Willard granite parallel with its bedding, as if conformable to it, and extending southward to the top of Mount Willey; then, on the southeast side and foot of Mount Willey, the Mount Willard granite again, which becomes, five miles south of the Notch, at the Frankenstein cliff, a dark gray granite for some distance, and then changes abruptly to syenyte.* The andalusite slate where it adjoins the Mount Willard granite is, for a varying width—twenty feet below and two hundred feet above—an argyllyte-porphyry, it containing orthoclase and quartz, both of which minerals are in distinct crystals within a few yards of the granite.

The rocks of the *east* side of the valley are, just north of the Notch, well characterized gneiss; then, at the Notch and below it, the same hard granitoid gneiss that occurs on the west side, seldom distinct in dip and strike; then farther south, Conway or Mount Willard granite, at the base and up the slope of Mount Webster; and above this, far up the sides of this mountain, the "Montalban schists" (feldspathic mica schist chiefly), the characterizing rock of the Mount Washington range. The rocks of the region and of Mount Washington dip, with some local exceptions, to the westward.

The above facts respecting the rocks are here cited from the Report, as an introduction to a point of very prominent interest—the existence in the valley of a long series of great veins of coarse granite, and of a remarkable range of "breccia-granite." These veins are numerous and large at the Notch; and they occur also to the south, on nearly the same line, far up the western slope of Mount Webster, where some of them are twenty to thirty feet wide. The breccia-granite has the same general range with the veins. Just below the Notch, on its western side, there is a large exposure of it, and it here extends, Professor Hitchcock observes, "1,200 feet along the railway." Going southward in the gorge or valley, this breccia-granite appears at the outlet of Dismal Pool, and then, south of this, in a cliff on the west side of Mount Webster, at a height equal to that of the top of Mount Willard, where it has a thickness of two hundred to three hundred feet. Its course, southerly from the Notch, "is not in a right line, on account of various shiftings of the rock, not fully understood." This breccia-granite is made up of large and small masses of chiefly a dark micaceous gneiss, in a paste of granite, some of the masses a yard in length.

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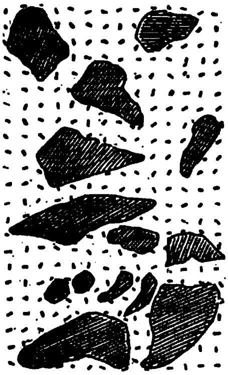
* According to the writer's observations at the place, the granite becomes syenyte by a substitution of hornblende for black mica (biotite). The other ingredients are precisely the same—gray feldspar and gray quartz, so that the two rocks are stratigraphically one. It is an interesting example of the abrupt transition between these two rocks, and is well worthy of a visit from those who are interested in lithological questions. The idea that the two rocks were perhaps upper and lower parts of one original stratum or successive strata was considered, but without finding reason to sustain it.

Again: a similar breccia-granite occurs one to two miles north of the Notch, (pp. 163, 165). Two miles southwest of Crawford's, on Cascade Brook, the Mount Willard granite "contains many fragments of the hard Montalban schists, sometimes from twelve to fourteen feet long; and several of them seem to carry andalusite quite abundantly."* Half a mile farther west up this same brook, andalusite slate succeeds to the granite (but with an intermediate porphyritic junction-rock, like that observed in Mount Willard), and it continues up Mount Tom.



The writer had the pleasure, in 1875, of examining this part of the White Mountain region with Professor Hitchcock, and adds here a cut representing a portion, six feet wide, of the surface of breccia-granite, just below the Notch.

The great number and large size of the granite veins extending along the gorge in a north-and-south direction, and the extensive range of breccia-granite following the same course, seem to sustain the opinion, which Professor Hitchcock quotes in his Report from the writer, that the gorge, like most valleys of the Appalachians, was probably the course of a lofty anticlinal, the fractures in which led to degradation and so determined the formation of the valley. And if this conclusion be right, the Mount Washington range may correspond to a nearly parallel synclinal. From the position of the rocks in the gorge above described, it seems probable that the hard siliceous granitoid gneiss of the Notch is the central and lowest rock of the anticlinal; that the Mount Willard (or Conway) granite is the next metamorphic stratum on *both* the east and west sides, it lying conformably against the slate in Mount Willard and elsewhere; and that the andalusite slate on the west and the Montalban schists (often andalusitic, and part an andalusitic slate) together on the east, constitute the succeeding stratum. The dissimilarity in the eastern and western portions of this last stratum may be a consequence of a small variation from east to west in the constitution of the sediments and of differences in the degree of metamorphism. The dissimilarity is chemically small; for the analysis of the andalusitic slate from this region by Mr. G. W. Hawes (Report, p. 233) found it to consist (No. 1, below) of—

	SiO_2	AlO_3	FeO_3	FeO	MnO	MgO	K_2O	Na_2O	TiO_2	H_2O
1.	46·01	30·56	1·44	6·85	0·10	1·42	6·66	1·12	1·91	4·13=100·22
2.	46·23	33·08	3·48	...	...	2·10	8·87	1·45	...	4·12= 99·28

which corresponds very nearly to the constitution of common mica (muscovite), or rather the hydrous variety margarodite, one analysis of which is cited in No. 2; and also, for half of it, as Mr. Hawes suggests, to that of common feldspar (orthoclase). The slate is peculiar in affording so large a percentage of alkali (7·78), and so small of silica; but it varies in its silica, being in some places an "argillaceous quartzyte;" in others a "felsitic slate," weathering white.

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* A similar breccia-granite occurs in the Franconia Notch, near the Basin, where (p. 137 of Professor Hitchcock's Report) masses "of porphyritic granite, dark gneiss, hornblendic and other siliceous rocks, are cemented together by a light-colored feldspathic paste." Other localities also are mentioned.

This view that the andalusite-slates and Montalban schists (which also are often andalusitic) correspond to a stratum *higher* in the series than the Mount Willard granite is sustained by the occurrence of masses of them in the bed of granite on Cascade Brook (see above); for in the fracturing and crushing of the rocks, the detached masses would naturally fall to the level of the lower strata from those above. The breccia-granite the writer attributes to a crushing of the walls of great fractures during the period of upturning and metamorphism,—the metamorphism of the fragments and of the rock fractured, and the making of the granite, having gone on in the same epoch, like the making of the granitic veins; and not, as held by Professor Hitchcock, to the breaking up of schists long before made by metamorphism, and the including of the fragments in eruptive granite. The crushing was on a vast scale; and it may have been far beyond what is now indicated; for we cannot know to what extent the stratum which is now Mount Willard granite was crushed, all trace of bedding being obliterated. What is apparent shows where the heat required for metamorphism, and for the making of granite, came from.

The strike of the andalusite slate from its southern point at the summit of Mount Willey, northward, is, according to Professor Hitchcock, N. 10° E., and it varies little from this except adjoining the Mount Willard granite, where for one or two hundred rods it has a bend to the westward. The northern limit of the narrow slate area is in the high region northwest of Mount Willard, the whole length being about ten miles. A finely porphyrytic or "spotted" granite named the "Albany granite," is stated to bound it on the west and to occur where it disappears to the north. Whether the slate disappears by dipping beneath the granite, or by passage into it, is not stated. This Albany granite is in the larger part a granite without quartz (p. 143), and hence may have nearly the constitution of the slate.

Professor Hitchcock states that the porphyritic granitoid rock, ten to two hundred feet wide, which marks the junction in Mount Willard of the andalusite slate and Mount Willard granite, resembles the "Albany granite." This peculiar junction-rock indicates, in the writer's view, that the stratum of granitic mud or sand from which the Mount Willard granite was made, and that from which the andalusitic slate proceeded, had some beds of passage; there was a transition in the metamorphic products because of a transition in the material and in other conditions.

The structure of the White Mountains is so exceedingly complex, that it may reasonably give rise to widely diverse explanations. The view the writer has here presented seems at least to be worth considering in the future study of the region.

The volume also treats of the rocks of the Merrimack district, the Lake district, the Coast district, and the district of northern New Hampshire.

The Geological Map, illustrating this volume, is in the hands of the engraver. It is on a scale of two and a half inches to the mile.

The third and last volume of the Survey will contain a report by Mr. Warren Upham on the Quaternary of New Hampshire; and one by Mr. George W. Hawes, on the Lithology of the State, both chemically and microscopically considered. J. D. D.

3. *Preliminary Report on the Paleontology of the Black Hills*, by R. P. Whitfield. U. S. Geogr. and Geol. Survey of the Rocky Mountain region, J. W. Powell in Charge. 50 pages, 8vo, July, 1877. Washington.—This valuable report contains descriptions of new species of fossils from Primordial, Jurassic and Cretaceous formations; and in the final report on the paleontology of the Black Hills, it will be accompanied with sixteen lithographic plates. The new Primordial fossils include besides a fucoid, two species of *Lingulepis*, and two of trilobites of the genus *Crepicephalus* (*Loganellus*), *C. centralis*, and *C. planus;* the new Jurassic, species of *Pecten*, *Pseudomonotis*, *Mytilus*, *Trapezium*, *Pleuromya*, *Tancredia*, *Dosinia*, *Psammobia*, *Neæra*, *Saxicava;* and besides there are eighteen new species of Cretaceous fossils. In all, the number of Jurassic species recognized from the Black Hills by Mr. Whitfield, is thirty-three, and of Cretaceous species, seventy. The sixteen lithographic plates are full of well-drawn and finely engraved figures.

4. *The Age of the Tejon group, California.*—The following is from a paper by Dr. J. G. Cooper in the Proceedings of the California Academy of Sciences, for Nov. 16, 1874.—The evidence of the age of the Tejon group is so far derived from only a few marine fossils which have been referred by different authors to the Cretaceous, the Eocene, and the Miocene. Conrad, the Nestor of American paleontologists, over twenty years ago, described as unmistakably Eocene, a group of fossils, now known as the Tejon group, among which he thought was the *Cardita planicosta*, "that finger-post of the Eocene, both in Europe and America." Mr. Gabb, finding from better specimens that this shell differed from *Cardita planicosta*, described it as new, and referred the Tejon group to the Cretaceous, finding in it a very few species which he considered identical with the lower beds, proved to be Cretaceous by the presence of numerous Ammonites. He also stated, in an article in our Proceedings, published November, 1866, that "a solitary ammonite, represented by half a dozen specimens, has been found by myself *in place*, even to the very top of the formation." This slender evidence (which might be rejected after finding a Carboniferous fossil in a Pliocene deposit) is all the proof we have of the Tejon beds being Cretaceous; and that it is quite arbitrary is shown by the other fossils found with it being nearly all different from the lower ones, less than one-tenth of the Cretaceous shells being

common to both according to Gabb, of which several *may be* distinct. On the other hand, many of the Tejon group are scarcely distinguishable from Tertiary and living forms. One, *Aturia Mathewsonii*, is so near the Eocene *A. zigzag*, as to have been taken for it, no other Cretaceous *Aturia* being known.

I may add that the ammonite (*A. jugalis* Gabb) was found by me in a stratum just beneath the Mt. Diablo coal, and apparently on the same level as those from Clayton and "Curry's," found by Gabb, so that its existence above the Coal, or in the Tejon group itself, is perhaps accidental. But, to pass by this doubtful fact, we have still later strata, referred to the Eocene by Conrad, near the mouth of the Columbia, where we would expect the first Tertiary to rise near the surface, and this time the Eocene *Aturia zigzag* again appears, though with a different group of shells. Mr. Gabb, while admitting that this time it is the true *zigzag*, is so opposed to recognizing any Eocene here, that he calls the formation Miocene. The general character of these fossils, of which there are several in the Academy's Museum, shows, however, that they are of a more tropical growth than any of our Miocene species, the *Aturia* itself being very similar to the *Nautili* now living in the tropics. Though perhaps mixed with Miocene species among the broken rocks so numerous on the lower Columbia shores, it is most probable that true Eocene strata exist there, and, as shown by the Academy's specimens, extend south nearly to California, where later strata cover them. From all we yet know, we may assume that the gap between the Cretaceous and Tertiary, so marked on the Atlantic shores, was bridged over in part by the existence here of the "Tejon Group," continuing Cretaceous forms of mollusca down so as to be contemporaneous with the Eocene epoch there, or the earlier part of it, just as we find the flora and fauna of Australia resembling forms fossil in the Eocene formation of Europe, but continued to the present epoch. After, perhaps, a short geological period of convulsion and death, we find the Eocene mollusca appearing in Oregon, just preceding the Miocene, nearly like those of the Atlantic basin.

5. *Fossil Tertiary Insects of Quesnel, British Columbia.*—Mr. S. H. SCUDDER has described, in the Canada Geological Report for 1875–76, the following Columbian Tertiary species of insects. HYMNOPTERS: *Formica arcaria*, *Pimpla saxea*, *P. senecta*, *Calyptites* (n. gen.) *antediluvianum*. DIPTERS: *Boletina sepulta*, *Brachypeza abita*, *B. procera*, *Trichonta Dawsoni*, *Anthomyia inanimata*, *A. Burgessi*, *Heteromyza senilis*, *Sciomyza revelata*, *Lithortalis* (n. gen.) *picta*, *Lonchœa senescens*, *Palloptera morticina*. COLEOPTERA: *Prometopia depilis*. HEMIPTERA: the Aphid, *Lachnus petrosum*, with mention of an imperfect specimen of a Neuropter.

6. *On the first discovered traces of Fossil Insects in American Tertiaries, and on new Carabidæ from the interglacial deposits of Scarborough Heights, near Toronto, Canada*, by SAMUEL H. SCUDDER. From the Bulletin of the U. S. Geol. and Geogr. Survey, F.

V. Hayden, U. S. Geol.-in-Charge.—The Tertiary Insects described by Mr. Scudder include species of Hymenoptera of the families *Formicidæ*, and *Ichneumonidæ;* Diptera of the families *Culicidæ*, *Chironomidæ*, *Cecidomyidæ*, *Tipulidæ*, *Mycetophilidæ*, *Cyrtidæ*, *Synphidæ*, *Muscidæ* and *Helomyzidæ;* various Coleoptera and Hemiptera; and a Neuropter of the genus *Phryganea.*

7. *Geological Survey of Victoria*, No. IV. *Report of Progress* by the SECRETARY OF MINES, *with Reports on the Geology, Mineralogy and Physical Structure of various parts of the Colony*, by R. A. F. MURRAY, F. M. KRAUSÉ, N. TAYLOR, A. W. HOWITT, W. NICHOLAS, J. COSMO NEWBERY, and Professor F. MCCOY.—The Report of Progress states the following facts brought out in Decade IV of the Prodromus of the Paleontology of Victoria by Professor McCoy, which is nearly ready for issue. Three plates are devoted to the *Diprotodon* which, "like the Megatherium of South America, was obviously a feeder on the twigs and foliage of trees, like their diminutive representatives of modern times." On Plate V are represented *Favosites Goldfussi*, "agreeing in every respect with the European Devonian coral," *Spirifera lævicosta*, a species also of England and abounding in the Middle Devonian limestones of the Eifel, *Chonetes Australis*, "closely allied to the *C. sarcinulata* of the Rhenish Devonian beds," *Asterolepis ornata*, "almost identical with specimens found in the Russian Old Red Sandstone;" on Plate VI are figures of *Archæopteris Howitti*, *Sphenopteris Iguanensis*, and *Cordaites Australis*, from the Upper Devonian of Gippsland.

Mr. Howitt describes the basalts, and other rocks of North Gippsland, and gives figures of thin slices of the rocks, with detailed descriptions. The volume contains also facts on other formations in Victoria, and much on auriferous veins.

8. *Tantalite.*—I have lately had sent to me a mass of tantalite, weighing about 500 grams, coming from Professor Eugene A. Smith, State Geologist of Alabama; its exact locality in Alabama is not given. It is the first time that tantalite has been found in the United States; its specific gravity is over 7·2. It is a surface specimen, and has undergone partial decomposition in the crevices. It is an important discovery at the present time, while this class of minerals is exciting interest. J. LAWRENCE SMITH.

9. *Geognostische und geographische Beobachtungen im Staate Minnesota.* Doctorate Inaugural dissertation by J. H. KLOOS, Mining Engineer of Amsterdam. 58 pp. 8vo. Berlin, 1877.

III. BOTANY AND ZOOLOGY.

1. *Morphology of the Dentary System in the Human Race.*—Dr. E. LAMBERT, of Brussels, has given the characteristics of the teeth in the different races of Man a careful study, and has arrived at the following important conclusions, here derived from the Bulletin of the Royal Academy of Belgium, 46th year, No. 5, 1877.

In the *white race*, the triturating surface of the canines does not project beyond that of the other teeth, the two premolars are equal in volume, the first true molar is the largest, and the last or wisdom tooth is the smallest. In the *black race*, the contrary is true in all these points, the canines projecting beyond the teeth adjoining, the posterior premolar being the largest, and the true molars increasing in size posteriorly.

In the white race, the molars have ordinarily only four cusps; in the black, five. If in the white race there are five, it is the first molar which has them; while in the black it is the last.

In the yellow race, there is usually a slight increase in the size of the molars from the interior to the posterior, as in the black race; and, as in the black race, there is a fifth cusp on the wisdom tooth.

In the black race, the diameters of the incisors are larger than in the white race, and the triturating surface of the canines is larger than that of the teeth adjoining.

In the black race, there is a slight diastema, which does not exist in the white race, and the inner tubercle of the premolar is less developed than the outer—as in the man-apes. In the inferior premolars, the first has often an inner tubercle feebly developed, which again manifests a slight approximation toward the man-apes.

In the black race, the superior molars have the antero-posterior diameter equal to the bi-lateral; in the white race, it is always smaller, and, in the yellow, the form is intermediate.

There is more difference in the teeth between the black race and the yellow than between the yellow and the white. However, the Malay branch, the type of the brown race of D'Omalius, seems to be transitional between the black and the yellow as regards the general volume of the teeth, the number of cusps of the large inferior molars, and the tendency to an increase of size of molars posteriorly.

The American race—the red race of D' Omalius usually united with the yellow—presents so nearly the dentary characters of the black race that Dr. Lambert unites the two. The Australians, Tasmanians, and New Caledonians present, in some respects, an exaggeration of the dentary characters of the African negro, and also stronger prognathism.

The crania from the caves of Furfooz (Belgium), have the inferior molars decreasing in size backward, as in the white race; and it is the same with the seventy neolithic crania exhumed at Hastières. But the Paleolithic lower jaw from Naulette (Belgium), as has been remarked by MM. Prüner Bey, Broca and Carter Blake, approximates most that of the Australian and New Caledonian races, showing a resemblance in the age of the mammoth between man in Belgium and the existing races of their antipodes. Dr. Lambert's paper is published at length in the Bulletin of the Academy.

2. *Arbeiten aus dem zoologische-zootomischen Institut im Würtzburg.* 8vo. Herausgegeben von Prof. Dr. Carl Semper.—

The third volume contains the following elaborate papers: The Uranogenital system of the Amphibia, by Dr. J. W. SPRENGEL, 114 pages, with 3 folded plates; Strobilation and Segmentation in articulate animals, with special reference to the homologies between Vertebrates, Annelids, and Anthropods, by C. SEMPER, 290 pages, with 12 folded plates; Studies on the Turbellaria (on the Plathelminthids) by CHARLES SEDGWICK MINOT, of Boston, 62 pages, with 5 plates; on the saliva and cement glands of the Decapods, by Dr. M. BRAUN, 8 pages, with 1 plate; Remarks on the "Nephrofneusten" of v. Ihering, by C. SEMPER.

3. *On the Brain of Chimæra monstrosa*, by B. G. WILDER, Proc. Acad. Nat. Sci. Philad., May 29, 1877. 34 pp. 8vo, with a plate.

IV. ASTRONOMY.

1. *New Planets.*—In a letter to the editors Prof. Watson says: "The following are the places, from the observations provisionally reduced, of the two planets recently discovered by me.

Planet (174) discovered August 8th, magnitude 10·3.

Ann Arbor.	Mean Time.	(174)α.	(174)δ.	No. Comp.
	h m s	h s	° ′ ″	
1877, August 8,	10 50 0	21 22 39·10	−16 4 7·0	2
16,	13 48 1	21 13 57·94	15 46 6·0	5
17,	9 39 25	21 13 5·89	15 44 8·0	5
18,	10 40 5	21 12 0·29	15 41 34·8	5
20,	11 11 13	21 9 55·43	15 36 30·4	5
26,	9 56 30	21 4 9·13	15 19 58·1	5
30,	12 15 30	21 0 33·55	15 7 29·1	2
Sept. 1,	9 48 4	20 59 3·24	15 1 27·9	9
3,	8 53 48	20 57 34·90	14 54 53·6	5

Planet (175) discovered September 2d, magnitude 11·5.

Ann Arbor.	Mean Time.	(175)α.	(175)δ.	No. Comp.
	h m s		° ′ ″	
1877, Sept. 2,	11 2 58	23 10 4·80	+0 44 59·1	5
2,	13 50 35	23 9 58·39	0 44 50·2	5
3,	10 40 9	23 9 10·38	0 43 36·9	6
4,	10 11 56	23 8 16·21	+0 42 11·3	5

Observatory, Ann Arbor, September 10, 1877.

2. *Time of Rotation of Saturn.*—Professor HALL discovered on the night of December 7th, a bright spot on the ball of Saturn. Notice was sent to various astronomers and the spot was observed at Poughkeepsie, Albany, Hartford, etc. The spot was followed, and its position measured at Washington until Jan. 2d, or through more than sixty revolutions. Assuming that the spot had no proper motion on the surface of Saturn, Professor Hall obtains for the time of one revolution on its axis

$$10^{h}\ 14^{m}\ 23^{s}\cdot8 \pm 2^{s}\cdot30.$$

The only earlier determination of this quantity was made by Sir Wm. Herschel in 1793–4 who found it to be $10^{h}\ 16^{m}\ 0^{s}\cdot4$, which he believed could not be in error as much as two minutes. By a curious mistake his time for the rotation of the ring, or $10^{h}\ 29^{m}\ 16^{s}\cdot8$, has been hitherto given in almost all treatises on astronomy as the time of rotation of the planet itself.

3. *The newly discovered satellites of Mars.*—The announcement of this remarkable discovery made by Prof. Hall was too late to appear in the body of the September number of the Journal, but was given upon the third page of the cover. It is of such exceptional importance that we give in full Admiral Rodgers' Report to the Secretary of the Navy, dated August 21st.

"Sir: the outer satellite of Mars was first observed by Professor Asaph Hall, U. S. N., on the night of the 11th of August, 1877. Cloudy weather prevented the certain recognition of its true character at that time. On August 16th it was again observed, and its motion was established by observations extending through an interval of two hours, during which the planet moved over thirty seconds of arc. The inner satellite was first observed on the night of August 17th, and was also discovered by Professor Hall. On Saturday, August 18th, the discoveries were telegraphed to Alvan Clark and sons, Cambridgeport, Mass., in order that if the weather should be cloudy at Washington, they might confirm the existence of the satellites with the 26-inch telescope of Mr. McCormick, which is in their hands. This discovery was confirmed by Professor Pickering and his assistants, at Cambridge, Mass., and by the Messrs. Clark, at Cambridgeport. On August 19th the discovery was communicated to the Smithsonian Institution, by which it was announced to the American and European observatories in the following dispatch:

Two satellites of Mars discovered by Hall, at Washington. First, elongation west, August 18, eleven hours, Washington time. Distance eighty seconds. Period, thirty hours. Distance of second, fifty seconds.

It will be seen hereafter that the statement of fifty seconds as the distance of the inner one was erroneous. The observations hitherto made are as follows:

The First Satellite.

		h m	°	h m	″		
1877, Aug.	11,	14 40,	$p=$ 59·6 (2);	14 45,	$s=$70·57 (2)	Obs.,	Hall.
	16,	11 42,			$s=$77·6: (1)	"	Hall.
		13 7,	$p=$ 71·9 (2)		$s=$80·83 (4)	"	Hall.
		13 36,			$s=$80·4 (1)	"	Hall.
	17,	16 2,	$p=$ 85·5 (2);	16 19,	$s=$63·24 (3)	"	Hall.
	18,	10 28,	$p=$251·7 (3);	10 18,	$s=$82·93 (8)	"	Newcomb.
		10 57,	$p=$244·5 (1);	11 5,	$s=$81·6 (1)	"	Harkness.
		11 50,	$p=$246·6 (4);	11 57,	$s=$81·77 (4)	"	Hall.
		14 32,	$p=$232·1 (4);	14 39,	$s=$61·04 (4)	"	Hall.
	19,	11 42,	$p=$283·2 (2);	11 49,	$s=$46·20 (4)	"	Hall.
		15 43,	$p=$255·4 (4);	15 52,	$s=$81·37 (6)	"	Hall.
	20,	10 28,	$p=$ 61·1 (3);	10 33,	$s=$76·07 (2)	"	Hall.
		11 57,	$p=$ 52·1 (4);	12 7,	$s=$59·93 (4)	"	Hall.

The Second Satellite.

		h m	°	h m	″		
1877, Aug.	17,	16 6,	$p=$ 73·0 (2);	16 21,	$s=$30·81 (4)	Obs.,	Hall.
	18,	11 31,	$p=$248·8 (2);	11 37,	$s=$34·65 (4)	"	Hall.
	19,	11 25,	$p=$226·8 (2);	11 30,	$s=$24·08 (2)	"	Hall.
	20,	13 15,	$p=$ 67·1 (1);	13 26,	$s=$31·95 (3)	"	Hall.
		13 56,			$s=$27·02 (4)	"	Hall.
		14 22,	$p=$ 70 (est.);	14 22,	$s=$19·16 (3)	"	Hall.
		16 19,	$p=$250 (est.);	16 19,	$s=$15·15 (7)	"	Hall.
		16 35,			$s=$16·70 (7)	"	Hall.

From these observations Professor Newcomb has derived the following approximate circular elements of the orbits. The probable errors assigned are only very rough estimates.

The Outer Satellite.

Major semi-axis of apparent orbit seen at distance [9·5930]	82·″5 ± 0·″5
Minor semi-axis of apparent orbit seen at distance [9·5930]	27·″7 ± 2·″
Major semi-axis of orbit seen at distance unity	32·″3
Position angles of apsides of apparent orbit	70°, 250° ± 2°
Passage through the west apsis ($p=250°$), Aug. 19, 16·6h, W. m. t.	
Period of revolution	30h 14m ± 2m
Hourly motion in Areocentric longitude	11·°907
Inclination of true orbit to the ecliptic	25·°4 ± 2°
Longitude of ascending node	82·°8 ± 3°
Position of pole of orbit in celestial sphere	Long. 352·°8
	Lat. +64·6
	R.A. 316·1
	Decl. +53·8
These elements gave for the mass of Mars	$\frac{1}{3,090,000}$

The Inner Satellite.

Major semi-axis of apparent orbit at distance [9·5930]	33·″0 ± 1″
Period of revolution	7h 38·5m ± 0·5m
Hourly motion in Areocentric longitude	47·°11
Passage through the eastern apsis ($p=70°$), Aug. 20, 13·0h, W. m. t.	

4. *The American Ephemeris and Nautical Almanac for the year* 1880, has been issued, under the superintendence of Professor Coffin, by the Bureau of Navigation at Washington.

5. *Does the Motion of the inner satellite of Mars disprove the Nebular Hypothesis?* by Professor DANIEL KIRKWOOD. (Letter to the Editors.)—From eight measurements of the position and distance of the inner satellite of Mars as taken by Professor Hall within three days from the date of his first observation, Professor Newcomb found the period to be seven hours and thirty-eight minutes. On the theory, therefore, of a circular orbit the satellite is within 3400 miles of the planet's surface. Professor Hall remarks that the diameters of the Martial satellites are extremely small, probably not more than 50 or 100 miles. It is interesting to observe that even with the larger limit the bodies are smaller in comparison with their primary than any other secondaries in the solar system. According to Proctor, Mars revolves on its axis in $24^{h}\ 37^{m}\ 22{\cdot}735^{s}$. The inner satellite, therefore, completes three orbital revolutions in less than a Martial day. How is this remarkable fact to be reconciled with the cosmogony of Laplace?

Although the period of no other satellite is less than that of the rotation of its primary, the case can hardly be regarded as wholly unique. The rings of Saturn are clouds of extremely minute secondary planetoids revolving about the primary in approximate accordance with Kepler's third law. The periods of those in the outermost ring, like that of the exterior satellite of Mars, are somewhat greater than the rotation period of the primary. Those near the outer edge of the interior bright ring revolve in the same time with Saturn, and those at the inner visible edge of the dusky ring complete a revolution in about eight hours. "These rings of Saturn, like everything cosmical, must be gradually decaying, because in the course of their motion round the planet there must be continual impacts amongst the separate portions of the mass; and of two which impinge, one may be accelerated, but it will be accelerated at the expense of the other. The other falls out of the race, as it were, and is gradually drawn in towards the planet. The consequence is that, possibly not so much on account of the improvement of telescopes of late years, but perhaps simply in consequence of this gradual closing in of the whole system, a new ring of Saturn has been observed inside the two old ones,—what is called from its appearance the crape ring, which was narrow when first observed, but is gradually becoming broader. That is formed of the laggards, as it were, which have been thrown out of the race, and which are gradually falling in towards the planet's surface."*

The process by which, in the case of Saturn's rings, the period of revolution has become less than that of the planet's rotation is here clearly indicated. It is not impossible that a similar process may have been in operation during the forming period of the Martial system. Unless some such explanation as this can be given, the short period of the inner satellite will doubtless be regarded as a conclusive argument against the nebular hypothesis.

Bloomington, Indiana, August 27th, 1877.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association for the Advancement of Science.*—The twenty-sixth meeting of the American Association opened at Nashville, on Wednesday, August 29th. Professor Newcomb, of Washington, was the President of the meeting. The local committee, consisting of Messrs. Lindsley, Lupton, Safford and others, citizens of Nashville, contributed greatly to the success of the meeting by the arrangements they had made for the reception and entertainment of the members, and for the convenience of the several sessions. The hospitality of the people was unbounded, and the provisions for excursions were of the most generous kind. The attendance was large, though not equal to that of some meetings, owing to the season of the year for a place so far south, and the distance (over a thousand miles) from the Atlantic sea-board.

Through the generosity of Mr. Samuel Watkins, of Nashville, and others of the local committee, there were sent to the association, for distribution among its members, 400 copies of a volume containing as follows: Second Annual report of the Board of Health, gotten out with special reference to this Association; report on the Topography of Nashville, by Major Wilbur F. Foster, illustrated with a map embracing an area of three miles; report on the Geology of Nashville, by Professor Safford, State Geologist; report on the Water-supply, with a careful analysis, by Professor

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* Tate's Recent Advances in Phys. Sci., p. 259.

Lupton; report upon the Climate of Nashville, by Dr. A. C. Ford, of the Signal Service; interesting facts in Nashville's history, taken from the newspapers and other sources, by Anson Nelson, Secretary of the Tennessee Historical Society; report by the Health officer upon the Sanitary condition of Nashville; a complete index, by Dr. George Blackie. Dr. Lindsley, through whom the gift was made, said that it was intended as a memorial volume. The gift was received with a hearty vote of thanks.

The place appointed for the meeting in 1878 was St. Louis, and the time, the third Wednesday in August. Professor O. C. **Marsh** was elected President for the ensuing year; R. B. **Thurston**, of Hoboken, New Jersey, Vice-President of Section A; A. R. **Grote**, of Buffalo, Vice-President of Section B; and H. C. **Bolton**, General Secretary.

The retiring President, Professor W. B. Rogers, was unable to be present at the meeting, and hence the occasion failed of a Presidential Address, which in this case was looked for with high expectations.

The evening session of Wednesday was occupied with a lecture, by Professor Newcomb, on the recent astronomical discoveries—that of the Satellites of Mars by Professor Asaph Hall, and that of oxygen in the atmosphere of the sun by Professor Henry Draper; remarks, by Professor James Hall, on the history of the Association, and the work it had done; a lecture, by Professor J. Lawrence Smith, on meteoric stones; and a paper, by Professor A. R. Grote, on an International Scientific Service.

Professor Marsh, the Vice-President of Section B, occupied Thursday evening with a discourse on the "Introduction and Succession of Vertebrate Life in America," which was rich in facts from his own hard work among the vertebrate fossils of the Rocky Mountain region and other parts of the continent, also from the extended observations of Leidy, Cope, and other investigators in the same field, and which set forth the succession of vertebrate life, and the bearing of the whole on its introduction, with a fulness, as regards mammals, before unequalled. Professor Marsh's paper will appear in the following number of this Journal. On Monday a very valuable discourse was delivered by Professor Daniel Wilson "on the races of America."

The number of important papers read in the several sections was small. The following is a list of those read or accepted for reading.

I. *Section of Mathematics, Astronomy and Physics.*

On a New Type of Steam Engine, theoretically capable of utilizing the full Mechanical Equivalent of Heat Energy; and on some points of Theory indicating its practicability, R. H. **Thurston**.—On a new method of planning researches, and of representing to the Eye the Results of Combination of three or more Elements in all possible proportions, id.—The work of the U. S. Board appointed to test iron, steel and other metals, id.

On the proper motion of the Trifid Nebula, M. 20, G. C. 4355, etc., E. S. **Holden**.

A new Quadruple Objective for Astronomical Telescopes, E. **Gundlach**.—A new Periscopic Eye-piece, id.

On the arbitrary coefficient A $(^2)$ in Laplace's expression for the semi-diurnal tide, J. G. Barnard.

Mechanics of the flight of birds, A. C. Campbell.

The Physics of the Mississippi river below the Red river, C. G. Forshey.—The Physics of the Gulf of Mexico, id.

On a Measurement of the wave-length of the Blue line of the Spectrum of Indium, T. C. Mendenhall.—On the proposed modification in the Metric System in its Introduction into the United States, id.

Improvement in use of the Reflecting Goniometer, H. W. Wiley.

A novel Radiometer, Mr. Jeffrey.

The Monetary Question, E. B. Elliott.—On Standard Time, id.

On the Relation of Organ to Function; or of Form in general to Mode of Energy Received and Exerted, R. L. Kirkpatrick.

II. *Subsection of Chemistry and Mineralogy.*

A Steam blast for general use in laboratories, with illustrations of same, J. L. Smith.—Use of a current of steam in boiling liquids with and without precipitates for use in the analytical laboratory, id.—Some remarks on Phosphorus in Iron, id.—A peculiar Silicide of Iron with remarks on artificial Silicides of the metal, id.—On the general methods adopted in the analyses of the American Columbates, id.—On an American tantalite, id.

The action of Dilute Acid upon Ferrous Sulphide made from Cast-iron, F. P. Dunnington.—The Minerals of a Deposit of Antimony Ores in Sevier County, Arkansas, id.

Ethers of some Bile Acids, and specimens, A. Springer.

On the use of Hyposulphite of Soda for the precipitation of Alumina, C. L. Mees.

The various methods of separating and determining Barium, Strontium and Calcium. Part I. Determination of Strontium, P. Schweitzer.—On some interesting deductions from the solubility of difficultly soluble substances, id.

Note on the Separation of Iron from Cobalt and Nickel, A. H. Elliott.

On the manufacture of steel by the open hearth process, B. S. Hedrick.

III. *Section of Geology and Natural History.*

Our Knowledge of the Cotton Worm, A. R. Grote.—A new Lepidopterous Insect Injurious to Vegetation, id.

On Sex in Flowers, T. Meehan.

The Law of Repetition, Miss Virginia K. Bowers.

On the Respiration of Amia, B. G. Wilder.

Agamous reproduction among the Cynipidæ, H. F. Bassett.

On the Origin of Structural Variation, E. D. Cope.—On the Classification of the Extinct Fishes of the Lower types, id.

On the Silurian Island of the Cincinnati uplift with reference to its part in Tennessee, J. M. Safford.—Notice of a specimen of Cyrtodonta ventricosa from the Lower Silurian, id.

On the Geographical and Geological Distribution of the genus Beatricea, and of certain other Fossil Corals in the Rocks of the Cincinnati Group, N. S. Shaler.—On the Original Connection of the Eastern and Western Coal-fields of the Ohio Valley, id.—On the continuation of the folds of the Alleghany Chain to the North of the Delaware River, id.—On the Recent Formation of a small Anticlinal Axis in Lincoln County, Kentucky, id.

New specimens from the Water Lime Group at Buffalo, A. R. Grote and W. H. Pitt.

On Geodes, S. J. Wallace.

On the Annual Deposits of the Missouri River during the Post-Pliocene, J. E. Todd.

The Structure of Eruptive Mountains, J. W. Powell.—Overplacement, id.

The Variation of certain Fresh Water Mollusks of the United States and their Geographical Distribution, A. G. Wetherby.

Notes on the Silurian waters of Washoe, Nevada, T. Sterry Hunt.—Notes on the Geology of the Rocky Mountains, id.

Geology and Topography of the Oil Region of Tennessee and the Oil Springs and Wells, J. B. Killebrew.

Geology of the Region on the Headwaters of the Androscoggin River, J. H. Huntington.

A section of McKinny Hill, Tennessee, E. L. Drake.

Geological position and mode of origin of Hydrated brown oxide of Iron, E. T. Cox.

On the Fibre of Gossipeum herbaceum (cotton plant) considered with reference to a practical application of its manufacture, J. A. Ridley.

On the use to be made of the Post Route Maps in the advancement of Science, B. S. Hedrick.

Atmospheric Concussion as a Means of Disinfection, Mrs. H. R. Ingram.

IV. *Subsection of Anthropology.*

On the Origin of the Japanese, S. Isawa.

The former and present numbers of our Indians, G. Mallery.

Additional Facts concerning Artificial Perforation of the Cranium in Ancient Mounds in Michigan, H. Gilman.

Habits of the Moqui Tribe, E. A. Barber.

Some Popular Errors concerning the North American Indians, J. W. Powell.
—Introduction to the Study of Indian Language, id.

On the ancient excavations in Western North Carolina, A. A. Julien.

Report on the Exploration of the Graves of the Mound Builders in Scott and Mississippi Counties, Missouri, H. N. Rust.

Observations on the skull of the Comanche, T. O. Summers, Jr.

2. *Distant Points visible from Mt. Washington;* by W. H. Pickering. (Read October 11, 1876). If an observer were to go up four particular peaks in the White Mountains, he could see all the distant points visible from any of the other summits, together with a good many more not visible from them. These four peaks are Washington, Moosilauke, Passaconnaway and Lafayette. I name them in the order of the extent of the distant views obtained from them alone. Now looking at the subject the other way, no matter from what distant point the White Mountains are seen, one of these four peaks must always be the most conspicuous object in the view, provided no near hills intervene. By means of the following formulæ the distance visible from any mountain may be readily calculated, and also the elevation a mountain must have in order to see a certain distance: $d = \frac{1}{10}\sqrt{175h}, h = \frac{4}{7}d^2$, where $d =$ distance in miles, and $h =$ elevation in feet. They may also be used to calculate mountain profiles as seen from distant points.

The following is a list of some of the more interesting distant points to be seen from Mt. Washington, many of them being visible only on rare occasions.

Mt. Belœil, Canada: distance 135 miles, position north 45° west, and nearly over Prospect Hill, Lancaster. It is quite a high mountain near Montreal, and is said to be visible. Lake Memphremagog, north border of Vermont: distance 70 miles, position north 40° west, and over Jefferson Hill. It requires a very clear day, as distant water is difficult to distinguish.

Mt. Carmel, Maine: distance 65 miles, position north 10° east, and just over Mt. Adams. It is very near the northern border of Maine, and is readily recognized by the steep slope on the eastern side. It is said that a very fine view may be obtained from it. Mt. Bigelow: distance 70 miles, position north 35° east, and nearly over Mt. Hayes. It appears as three rounded hills. Just to the south of it and far beyond is a mountain with a very sharp apex, which is sometimes called Katahdin, but this is a mistake. Mt. Abraham: distance 65 miles, position north 40° east, and somewhat to the right of Mt. Hayes. A long serrated ridge, also sometimes called Katahdin. Mt. Katahdin, Maine: distance 163 miles, position north 45° east, and about half way between Mt. Hayes and Mt. Moriah. It is said to appear rising over a nearer saddle-shaped mountain, and to be recognized by its sharp peak—the sharpest in all the view from Washington. If visible at all in summer, it would be far the faintest object in sight in that direction. Mt. Blue, Maine: distance 57 miles, position north 57° east, and half way between Surprise and Moriah. It is quite a conspicuous pyramidal peak, and is near Farmington, Maine. It is used as a Coast Survey Station.

Portland, Maine: distance 65 miles, position south 51° east, and over the northern summit of Doublehead. It appears as a low white hill, with a long light blue line beyond it. With a telescope the hill resolves itself into a mass of closely packed white houses, and the blue line is seen to be thickly studded with sails. The Ocean, however, is not as often seen as some more distant objects in other directions, partly on account of the difficulty of distinguishing distant water, and partly because the atmosphere in this direction seems generally to be somewhat thicker than elsewhere. Lake Sebago, Maine: distance 43 miles, position south 48° east, and over Mt. Gemini. It is 14 miles long, and about 11 wide. Mt. Agamenticus, Maine: distance 80 miles, position south 24° east. A flat rounded hill of considerable height in the southern part of Maine, and forms a conspicuous landmark for sailors. Isles of Shoals, coast of New Hampshire: distance 97 miles, position south 22° east. They are very difficult to see, and are situated on the horizon just to the right of Agamenticus. Mt. Uncanoonuc, New Hampshire: distance 92 miles, position south 9° west, and half way between Mts. Crawford and Passaconnaway. Twin summits near Manchester. Mt. Wachusett, Massachusetts; distance 126·5 miles, position south 13° west, and just to the right of Whiteface, if it is visible. Mt. Monadnock, New Hampshire: distance 104·5 miles, position south 22° west, and a little to the right of Sandwich Dome. A very regular rounded summit. Mt. Kearsarge, New Hampshire: distance 70 miles, position south 24° west, and half way between Sandwich Dome and Carrigain.

Mt. Graylock, western Massachusetts: distance 147 miles, position south 40° west, and just over the summit of Mt. Webster. It has a pointed summit and is situated in the northwest corner of Massachusetts, near the Hoosac Tunnel, and is the highest mountain in the State, being 3,505 feet high, or about the same as Chocorua. It is extremely difficult to see, as it is, next to Katahdin, the most distant point visible. The Guide Book says it is 160 miles distant; this, however, is an error.

Mt. Ascutney, Vermont: distance 85 miles, position south 45° west. Situated in Windsor, Vermont, close to the Connecticut

River. Killington Peaks, Green Mountains: distance 91 miles, position south 59° west, and between Mts. Liberty and Blue. Twin peaked summits near Rutland, Vermont. Camel's Hump, Green Mountains: distance 80 miles, position north 87° west, and just over Bethlehem Street. It is a striking looking mountain, shaped like a truncated cone, with very steep sides. Readily visible at sunset on a clear day. Mt. Whiteface, Adirondack Mountains: distance 130 miles, position north 86° west. It is just barely visible, hardly rising above the right hand slope of Camel's Hump. This is one of the highest of the Adirondacks, rising to a height of 4,900 feet. Two lower peaks are seen just to the right, and three more some distance to the left. These however have not yet been identified, but if Mt. Marcy and any of the other higher summits are visible, they should appear about 7° to the south of Whiteface and nearly over the Fabyan House. Mt. Mansfield, Green Mountains: distance 78 miles, position north 78° west, and between the twin Mountain House and Mt. Deception. It is the highest of the Green Mountains, being 4,300 feet high, and appears as a long ridge bearing a fancied resemblance to a human face.—*Appalachia*, No. 2, March, 1877.

3. *Caution to Archæologists.*—The Archæological Section of the Academy of Sciences of St. Louis has issued a circular dated St. Louis, Mo., June 12, 1877, calling the attention of all lovers of science to the following statement of facts:—

"It is well known to all Archæologists that the Mississippi Valley contains a greater number of pre-historic remains than any other portion of the United States. It is the object of this Section to preserve these relics from destruction, and to keep such a record of their discovery and exhumation, as may render them available for scientific purposes. They find this work very much impeded by the operations of persons, who, under the direction of unprincipled traders, in this and other cities, are destroying in every direction the most interesting earthworks and other remains of the ancient races, with the sole object of making money by the sale of such articles as may be found therein.

Attention is also called to the fact, that imitations of the pottery from the Missouri Mounds are also being manufactured, and offered for sale as genuine antiquities. All who purchase collections from dealers thus obtain specimens that may be worthless; or, at best, have a greatly depreciated value, from the absence of the scientific data connected with their discovery.

To remedy this evil as far as possible, the Section has employed properly qualified persons to conduct explorations under their especial direction, and is willing to furnish to scientific bodies, or individuals interested in Archæology, specimens from the duplicates of its collection, either in exchange for articles from other localities, or by sale at a price sufficient only to cover the cost of procuring them. It is hoped that all who are desirous of promoting the interests of scientific enquiry, will aid the Section in its efforts, by refusing to purchase, or in any way countenance the mercenary traffic in antiquities."

The Secretary of the Society is Mr. F. F. Hilder, 604 North Fourth Street, St. Louis.

4. WILSON: *Handbook of Hygiene and Sanitary Science.* 3d edition, enlarged and re-written. 490 pp. 12mo. Philadelphia, 1877. (Lindsay and Blakiston.)—Dr. Wilson's well-known work is now placed, in its original English dress, before American readers. This is a clear, concise and sufficiently full description of the entire range of Sanitary Science, by a man of large experience as a health officer in the public service in Great Britain. The author has no pet theories to sustain and consequently is able to give to all matters falling under his review a fair consideration, while constant reference is made to authorities for fuller data than the limits of his work could admit. The subjects are treated in a systematic manner and the style makes agreeable reading of even the most technical portions. R. S.

5. *British Association.*—The meeting of the British Association for 1877, opened at Plymouth, on Wednesday, the 15th of August, and the address of the President, Professor Allen Thomson, was delivered on the evening of that day. The address of F. Galton before the section of Anthropology, and that of Mr. Pengelly before that of Geology, are republished on the preceding pages of this volume, from *Nature* of August 16 and 23. Sir William Thomson presented a paper advocating the doctrine suggested briefly in his Presidential address of 1875, that a meteorite might become the vehicle of animal life to this earth from another planet or heavenly body, and "was evidently listened to with much enjoyment." Much amusement was caused by his saying that "though the outside shell of a meteoric stone might be incandescent from the friction caused by its flight through the terrestrial atmosphere, yet within a crevice of that stone might be concealed a Colorado beetle, which, falling on the earth, might become the father of a large and prosperous family." A disbeliever in the doctrine, Professor Haughton, followed with objections, but said "that still he didn't care how many papa beetles came, so long as the mamma beetles were left at home." Among the more valuable papers were the following: on the rate of progression of groups of waves, and the rate at which energy is transmitted by waves, by Osborne Reynolds; on the effect of transverse stress on the magnetic susceptibility of iron, by Sir Wm. Thomson; unit of light for photometry, by A. Vernon Harcourt; on gallium, by Prof. Odling; a new method for studying the optical characters of minerals, by H. C. Sorby; result of tidal observations in the recent Arctic Expedition, by Prof. Haughton; also, by the same, on the best possible number of limbs for an animal; on the results of the North German Exploring Expedition in the west of Siberia, by Dr. Otto Finsch; on the Physical properties of solids and liquids in connection with the Earth's structure, by Professor Hennessy.

It was decided that the fiftieth or jubilee meeting of the Association—in 1881—be held in York, in consideration of the fact that its first meeting—that of 1831—was at that place.

6. *New Constructions in Graphical Statics;* by H. T. EDDY. Van Nostrand, New York: 1877. 8vo, pp. 62 and 9 folding plates. —This work is an application of the methods of Graphical Statics to the arch rib with and without joints, the suspension cable, the continuous girder, the retaining wall, the dome, etc.

The following publications of the U. S. Geological Survey of the Territories, F. V. Hayden in charge, have been received and will be noticed in another number; also other volumes whose titles follow:

Ninth Annual Report, embracing Colorado and parts of adjacent Territories, being a report of progress of the exploration for the year 1875, by F. V. Hayden. 827 pp. 8vo. Washington, 1877.

Report of the United States Geological Survey of the Territories, volume XI. Monographs of North American Rodentia, by Elliott Coues, Secretary and Naturalist of the Survey, and Joel Asaph Allen, Special Collaborator of the Survey. 1091 pp. 4to.

Miscellaneous Publications.—No. 7. Ethnography and Philology of the Hidatsa Indians, by Washington Matthews, Assistant Surgeon U. S. A. 239 pp. 8vo. —No. 8. Fur-bearing Animals: A Monograph of North American Mustelidæ, by Elliott Coues, Captain and Assistant Surgeon U. S. A. 348 pp. 8vo, with twenty plates.

Bulletin of the U. S. Geological and Geographical Survey of the Territories. Volume III, Number 4, August 5th, 1877.

Bulletin of the U. S. National Museum; No. 8.—Index to the names which have been applied to the subdivisions of the class Brachiopoda, by W. H. Dall. 88 pp. 8vo. Washington, 1877.

China: Ergebnisse eigener Reisen und darauf gegründeter Studien von Ferdinand Freiherrn von Richthofen; Band I, 758 pp. 4to, Berlin (New York, L. W. Schmidt).

Mesmerism, Spiritualism, etc. Historically and scientifically considered; being two Lectures delivered at the London Institution, by William B. Carpenter, C.B., etc. 158 pp. 8vo. New York, 1877. (D. Appleton & Co.)

Proceedings of the Davenport Academy of Natural Sciences, Volume I, Part I; January, 1876—June, 1877. Davenport, Iowa.

Jahres-Bericht des Naturhistorischen Vereins von Wisconsin für das Jahr 1876–77. Milwaukee.

The Western Review of Science and Industry, by Theodore S. Case. A monthly of 64 pages, published at Kansas City, Missouri, popular in its character.

Proceedings of the American Association for the Advancement of Science. Twenty-fifth meeting, held at Buffalo, N. Y., August, 1876. 368 pp. 8vo. 1877.

OBITUARY.

Professor HENRY NEWTON, E.M., Ph.D., Professor elect of Mining Engineering and Metallurgy of the Agricultural and Mechanical College of Ohio, at Columbus, died at Deadwood, Dak., on August 5th, in the 32d year of his age. Professor Newton was engaged in a geological examination of the Black Hills, which, begun two years ago, as Assistant Geologist to the United States Black Hills Expedition of the Interior Department. He was endeavoring to bring to completion this season, under the auspices of that branch of the geological explorations of the territories, in charge of Major Powell. Meanwhile Professor Newton, with great assiduity, had prepared a full report of his geological study of that region, with plates of fossils, and numerous drawings of sections and other important illustrations. The publication of this valuable report by the department, as it has more than once happened before with other reports of the same kind, had been grievously delayed—much to the annoyance and disappointment of its young and enthusiastic author, whose health became impaired under such an additional strain upon his nervous system, immediately after very close confinement to office-work. Uninitiated in the ways of the departments at Washington, Professor Newton found no means to proceed to the publication of his report for many months after its date—of the disadvantage of which circumstance he was no less conscious, than apprehensive of the likelihood of having devoted two years of solid work to no purpose. Its publication was provided for last spring, as a part of the series of reports of geological explorations of the territories in charge of Major Powell. With the object of bringing his work down to date, and of revising it by the light of recent industrial developments, Professor Newton returned this season to the Black Hills, where he was fatally stricken with mountain fever, while prosecuting his work.

Professor Newton was for a number of years attached to the School of Mines of Columbia College, where he received his degrees and was Assistant in Geology. During the same period he did excellent service upon the Geological Survey of Ohio. J. P. K.

MOSES STRONG, Assistant Geologist in the Geological Survey of Wisconsin, died on the 18th of last August. Mr. Strong was engaged in a geological examination of the branches of the Chippewa River, and was endeavoring to pass in a skiff some rapids on the Flambeau branch, when the boat was upset, and he was drowned in an attempt to save a young companion who was unable to swim. Earlier in the season, he had explored a large tract occupied by the copper-bearing formation in the region of the Upper St. Croix River, and had examined the Huronian formation of Barron County, and just before his last excursion in behalf of the Geological Survey, he had revised the proof of his contribution to the forthcoming Report of the Geological Survey on his results of the year past. He had also completed and revised the proofs of his report on the Lead region, "which is accompanied by a series of topographical and geological maps that have commanded the unqualified admiration of all who have seen them." Professor T. C. Chamberlain, the director of the survey, states further, that "as a co-laborer in the scientific investigation of the structure of the State, he enjoyed the unhesitating confidence and admiration of his associates. In character he was modest and unassuming, and commanded respect rather by the merits he could not conceal than by any that were assumed. To attractive personal traits he added an integrity that was absolutely above question and a candor and honesty of expression that was eminent."

Mr. Strong, after graduation at Yale College, with the class of 1867, pursued scientific studies at a German University, and had thus thoroughly fitted himself for the work in which he was engaged. He leaves a young wife and children.

Professor ADOLF ERMAN, an eminent German physicist, Professor in the Berlin University, died on the 13th of July, at the age of seventy-one.

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[THIRD SERIES.]

Art. XLII.—*Introduction and Succession of Vertebrate Life in America;* by O. C. Marsh.

[Address before the American Association for the Advancement of Science, at Nashville, Tenn., August 30, 1877.]

The origin of life, and the order of succession in which its various forms have appeared upon the earth, offer to science its most inviting and most difficult field of research. Although the primal origin of life is unknown, and may perhaps never be known, yet no one has a right to say how much of the mystery now surrounding it science cannot remove. It is certainly within the domain of science to determine when the earth was first fitted to receive life, and in what form the earliest life began. To trace that life in its manifold changes through past ages to the present is a more difficult task, but one from which modern science does not shrink. In this wide field, every earnest effort will meet some degree of success; every year will add new and important facts; and every generation will bring to light some law, in accordance with which ancient life has been changed into life as we see it around us to-day. That such a development has taken place, no one will doubt who has carefully traced any single group of animals through its past history, as recorded in the crust of the earth. The evidence will be especially conclusive, if the group selected belongs to the higher forms of life, which are sensitive to every change in their surroundings. But I am sure I need offer here no argument for evolution; since to doubt evolution to-day is to doubt science, and science is only another name for truth.

Taking, then, evolution as a key to the mysteries of past life on the earth, I invite your attention to the subject I have chosen: THE INTRODUCTION AND SUCCESSION OF VERTEBRATE LIFE IN AMERICA.

In the brief hour allotted to me, I could hardly hope to give more than a very incomplete sketch of what is now known on this subject. I shall, therefore, pass rapidly over the lower groups, and speak more particularly of the higher vertebrates, which have an especial interest to us all, in so far as they approach man in structure, and thus indicate his probable origin. These higher vertebrates, moreover, are most important witnesses of the past, since their superior organization made them ready victims to slight climatic changes, which would otherwise have remained unrecorded.

In considering the ancient life of America, it is important to bear in mind that I can only offer you a brief record of a few of the countless forms that once occupied this continent. The review I can bring before you, will not be like that of a great army, when regiment after regiment with full ranks moves by in orderly succession, until the entire host has passed. My review must be more like the roll-call after a battle, when only a few scarred and crippled veterans remain to answer to their names. Or rather, it must resemble an array of relics, dug from the field of some old Trojan combat, long after the contest, when no survivor remains to tell the tale of the strife. From such an ancient battle-field, a Schliemann might unearth together the bronze shield, lance-head, and gilded helmet of a prehistoric leader, and learn from them with certainty his race and rank. Perhaps the skull might still retain the barbaric stone weapon by which his northern foe had slain him. Near by, the explorer might bring to light the commingled coat of mail and trappings of a horse and rider, so strangely different from the equipment of the chief, as to suggest a foreign ally. From these, and from the more common implements of war that fill the soil, the antiquary could determine, by patient study, what nations fought, and, perhaps, when, and why.

By this same method of research, the more ancient strata of the earth have been explored, and, in our Western wilds, veritable battle-fields, strown with the fossil skeletons of the slain, and guarded faithfully by savage superstition, have been despoiled, yielding to science treasures more rare than bronze or gold. Without such spoils, from many fields, I could not have chosen the present theme for my address to-night.

According to present knowledge, no vertebrate life is known to have existed on this continent in the Archæan, Cambrian, or Silurian periods; yet during this time, more than half of the thickness of American stratified rocks was deposited. It by no means follows that vertebrate animals of some kind did not exist here in those remote ages. Fishes are known from the Upper Silurian of Europe, and there is every probability that they will yet be discovered in our strata of the same age, if not at a still lower horizon.

In the shore deposits of the early Devonian sea, known as the Schoharie Grit, characteristic remains of Fishes were preserved, and in the deeper sea that followed, in which the Corniferous limestone was laid down, this class was well represented. During the remainder of the Devonian, Fishes continue abundant in the shallower seas, and, so far as now known, were the only type of vertebrate life. These fishes were mainly Ganoids, a group, represented in our present waters by the Gar-pike (*Lepidosteus*) and Sturgeon (*Acipenser*), but, in the Devonian sea, chiefly by the Placoderms, the exact affinities of which are somewhat in doubt. With these were Elasmobranchs, or the Shark tribe, and among them a few Chimæroids, a peculiar type, of which one or two members still survive. The Placoderms were the monarchs of the ocean. All were well protected by a massive coat of armor, and some of them attained huge dimensions. The American Devonian fishes now known are not as numerous as those of Europe, but they were larger in size, and mostly inhabitants of the open sea. Some twenty genera and forty species have been described.

The more important genera of Placoderms are, *Dinichthys*, *Aspidichthys*, and *Diplognathus*, our largest Palæozoic fishes. Others are, *Acanthaspis*, *Acantholepis*, *Coccosteus*, *Macropetalichthys*, and *Onychodus*. Among the Elasmobranchs were, *Cladodus*, *Ctenacanthus*, *Machæracanthus*, *Rhynchodus*, and *Ptyctodus*, the last two being regarded as Chimæroids. In the Chemung epoch, the great Dipterian family was introduced with *Dipterus*, *Heliodus*, and possibly *Ceratodus*. Species of the European genera, *Bothriolepis* and *Holoptychius*, have likewise been found in our Devonian deposits.

With the close of the Devonian, came the almost total extinction of the great group of Placoderms, while the Elasmobranchs, which had hitherto occupied a subordinate position, increase in numbers and size, and appear to be represented by Sharks, Rays, and Chimæras. Among the members of this group from the Carboniferous, were numerous Cestracionts, species of *Cochliodus* of large size, with others of the genera *Deltodus*, *Helodus*, *Psammodus* and *Sandalodus*. Of the Petalodonts, there were *Antliodus*, *Chomatodus*, *Ctenoptychius*, *Petalodus* and

Petalorhynchus; and of the Hybodonts, the genera *Cladodus*, *Carcharopsis* and *Diplodus*. These Elasmobranchs were the rulers of the Carboniferous open sea, and more than one hundred species have been found in the lower part of this formation alone. The Ganoids, although still abundant, were of smaller size, and denizens of the more shallow and confined waters. The latter group of fishes was represented by true Lepidostidæ, of the genera *Palæoniscus*, *Amblypterus*, *Platysomus* and *Eurylepis*. Other genera are, *Rhizodus*, *Megalichthys*, *Ctenodus*, *Edestus*, *Orodus*, *Ctenacanthus*, *Gyracanthus*, and *Cœlacanthus*. Most of these genera occur also in Europe.

From the Permian rocks of America, no vertebrate remains are known, although in the same formation of Europe Ganoids are abundant; and with them are remains of Sharks, and some other fishes, the affinities of which are doubtful. The Palæozoic fishes at present known from this country are quite as numerous as those found in Europe.

In the Mesozoic age, the Fishes of America begin to show a decided approach to those of our present waters. From the Triassic rocks, Ganoids only are known, and they are all more or less closely related to the modern Gar-pike, or *Lepidosteus*. They are of small size, and the number of individuals preserved is very large. The characteristic genera are, *Catopterus*, *Ischypterus*, *Ptycholepis*, *Rhabdolepis*, and *Turseodus*. From the Jurassic deposits, no remains of fishes are known, but in the Cretaceous, ichthyic life assumed many and various forms; and the first representatives of the Teleosts, or bony fishes, the characteristic fishes of to-day, make their appearance. In the deep open sea of this age, Elasmobranchs were the prevailing forms, Sharks and Chimæroids being most numerous. In the great inland Cretaceous sea of North America, true osseous fishes were most abundant, and among them were some of carnivorous habits, and immense size. The more sheltered bays and rivers were shared by the Ganoids and Teleosts, as their remains testify. The more common genera of Cretaceous Elasmobranchs were, *Otodus*, *Oxyrhina*, *Galeocerdo*, *Lamna* and *Ptychodus*. Among the osseous fishes, *Beryx*, *Enchodus*, *Portheus* and *Saurocephalus* were especially common, while the most important genus of Ganoids was *Lepidotus*.

The Tertiary fishes are nearly all of modern types, and from the beginning of this period there was comparatively little change. In the marine beds, Sharks, Rays and Chimæroids maintained their supremacy, although Teleosts were abundant, and many of them of large size. The Ganoids were comparatively few in number. In the earliest Eocene fresh-water deposits, it is interesting to find that the modern Gar-pike, and *Amia*, the Dog-fish of our western lakes, which by their structure are seen to be remnants of a very early type, are well represented by species so closely allied to them that only an anatomist could separate the ancient from the modern. In the succeeding beds, these fishes are still abundant, and with them are Siluroids nearly related to the modern Cat-fish (*Pimelodus*). Many small fishes, allied apparently to the modern herring (*Clupea*), left their remains in great numbers in the same deposits, and, with them has been recently found a land-locked Ray (*Heliobatis*).

The almost total absence of remains of fishes from the Miocene lake-basins of the West is a remarkable fact, and perhaps may best be explained by the theory that these inland waters, like many of the smaller lakes in the same region to-day, were so impregnated with mineral matters as to render the existence of vertebrate life in them impossible. No one who has tasted such waters, or has attempted to ford one of the modern alkaline lakes which are often met with on the present surface of the same deposits, will doubt the efficiency of this cause, or the easy entombment of the higher vertebrates that ventured within their borders. In the Pliocene lake-basins of the same region, remains of fishes were not uncommon, and in some of them are very numerous. These are all of modern types, and most of them are Cyprinoids, related to the modern Carp. The Post-pliocene fishes are essentially those of to-day.

In this brief synopsis of the past ichthyic life of this Continent, I have mentioned only a few of the more important facts, but sufficient, I trust, to give an outline of its history. Of this history, it is evident that we have as yet only a very imperfect record. We have seen that the earliest remains of fishes known in this country, are from the lower Devonian; but these old fishes show so great a diversity of form and structure, as to clearly indicate for the class a much earlier origin. In this connection, we must bear in mind that the two lowest groups of existing fishes are entirely without osseous skeletons, and hence, however abundant, would leave no permanent record in the deposits in which remains of fishes are usually preserved. It is safe to infer, from the knowledge which we now possess of the simpler forms of life, that even more of the early fishes were cartilaginous, or so destitute of hard parts as to leave no enduring traces of their existence. Without positive knowledge of such forms, and considering the great diversity of those we have, it would seem a hopeless task at present to attempt to trace successfully the genealogy of this class. One line, however, appears to be direct, from our modern Gar-pike, through the lower Eocene *Lepidosteus* to the *Lepidotus* of the Cretaceous, and perhaps on through the Triassic *Ischypterus* and Carboniferous *Palæoniscus;* but beyond this, in our rocks, it is lost. The living Chimæra of our Pacific coast has nearly allied forms in the Tertiary and Cretaceous, more distant relatives in the Carboniferous, and a possible ancestor in the Devonian *Rhynchodus.* Our Sharks likewise can be traced with some certainty back to the Palæozoic; and even the *Lepidosiren*, of South America, although its immediate predecessors are unknown, has some peculiar characters which strongly point to a Devonian ancestry. These suggestive lines indicate a rich field for investigation in the ancient life-history of American fishes.

The Amphibians, the next higher class of vertebrates, are so closely related to the fishes in structure, that some peculiar forms of the latter have been considered by anatomists as belonging to this group. The earliest evidence of Amphibian existence, on this continent, is in the Sub-Carboniferous, where foot-prints have been found which were probably made by Labyrinthodonts, the most ancient representatives of the class. Well preserved remains are abundant in the Coal Measures, and show that the Labyrinthodonts differed in important particulars from all modern Amphibians, the group which includes our frogs and salamanders. Some of these ancient animals resembled a salamander in shape, while others were serpent-like in form. None of those yet discovered were frog-like, or without a tail, although the restored Labyrinthodont of the text books is thus represented. All were protected by large pectoral bony plates, and an armor of small scutes on the ventral surface of the body. The walls of their teeth were more or less folded, whence the name Labyrinthodont. The American Amphibians known from osseous remains are all of moderate size, but the foot-prints attributed to this group indicate animals larger than any of the class yet found in the old world. The Carboniferous Amphibians were abundant in the swampy tropical forests of that period, and their remains have been found imbedded in the coal then deposited, as well as in hollow stumps of the trees left standing.

The principal genera of this group from American Carboniferous rocks, are, *Sauropus*, known only from footprints, *Baphetes*, *Dendrerpeton*, *Hylonomus*, *Hylerpeton*, *Raniceps*, *Pelion*, *Leptophractus*, *Molgophis*, *Ptyonius*, *Amphibamus*, *Cocytinus*, and *Ceraterpeton.* The last genus occurs also in Europe. Certain of these genera have been considered by some writers to be more nearly related to the Lizards, among true reptiles. Some other genera known from fragmentary remains or footprints in this formation have likewise been referred to the true reptiles, but this question can perhaps be settled only by future discoveries.

No Amphibia are known from American Permian strata, but in the Triassic, a few characteristic remains have been found. The three genera, *Dictyocephalus*, *Dispelor* and *Pariostegus*, have been described, but, although apparently all Labyrinthodonts, the remains preserved are not sufficient to add much to our knowledge of the group. The Triassic foot-prints which have been attributed to Amphibians are still more unsatisfactory, and at present no important conclusions in regard to this class can be based upon them. From the Jurassic and Cretaceous beds of this Continent, no remains of Amphibians are known. A few only have been found in the Tertiary, and these are all of modern types.

The Amphibia are so nearly allied to the Ganoid fishes, that we can hardly doubt their descent from some member of that group. With our present limited knowledge of the extinct forms, however, it would be unprofitable to attempt to trace in detail their probable genealogy.

The authors to whom especial credit is due for our knowledge of American fossil Fishes and Amphibians, are Newberry, Leidy, Cope, Dawson, Agassiz, St. John, Gibbes, Wyman, Redfield, and Emmons, and the principal literature of the subject will be found in their publications.

Reptiles and Birds form the next great division of vertebrates, the Sauropsida, and of these the Reptiles are the older type, and may be first considered. While it may be stated with certainty that there is at present no evidence of the existence of this group in American rocks older than the Carboniferous, there is some doubt in regard to their appearance even in this period. Various foot-prints which strongly resemble those made by Lizards; a few well preserved remains similar to the corresponding bones in that group; and a few characteristic specimens, nearly identical with those from another order of this class, are known from American Coal Measures. These facts, and some others which point in the same direction, render it probable that we may soon have conclusive evidence of the presence of true Reptiles in this formation, and in our overlying Permian, which is essentially a part of the same series. In the Permian rocks of Europe, true Reptiles have been found.

The Mesozoic Period has been called the Age of Reptiles, and during its continuance some of the strangest forms of reptilian life made their appearance, and became extinct. Near its commencement, while the Triassic shales and sandstones were being deposited, true reptiles were abundant. Among the most characteristic remains discovered are those of the genus *Belodon*, which is well known also in the Trias of Europe. It belongs to the Thecodont division of Reptiles, which have teeth in distinct sockets, and its nearest affinities are with the Crocodilia, of which order it may be considered the oldest known representative. In the same strata in which the Belodonts occur, remains of Dinosaurs are found, and it is a most interesting fact that these highest of reptiles should make their appearance, even in a generalized form, at this stage of the earth's history. The Dinosaurs, although true reptiles in all their more important characters, show certain well marked points of resemblance to existing birds of the order *Ratitæ*, a group which includes the Ostriches; and it is not improbable that they were the parent stock from which birds originated.

During Triassic time, the Dinosaurs attained in America an enormous development both in variety of forms and in size. Although comparatively few of their bones have as yet been discovered in the rocks of this country, they have left unmistakable evidence of their presence in the foot-prints and other impressions upon the shores of the waters which they frequented. The Triassic sandstone of the Connecticut Valley has long been famous for its fossil foot-prints, especially the so-called "bird-tracks," which are generally supposed to have been made by birds, the tracks of which many of them closely resemble. A careful investigation, however, of nearly all the specimens yet discovered, has convinced me that there is not a particle of evidence that any of these fossil impressions were made by birds. Most of these three-toed tracks were certainly not made by birds; but by quadrupeds, which usually walked upon their hind feet alone, and only occasionally put to the ground their smaller anterior extremities. I have myself detected the impressions of these anterior limbs in connection with the posterior foot-prints of nearly all of the supposed "bird-tracks" described, and have little doubt that they will eventually be found with all. These double impressions are precisely the kind which Dinosaurian reptiles would make, and as the only characteristic bones yet found in the same rocks belong to animals of this group, it is but fair to attribute all these foot-prints to Dinosaurs, even where no impressions of fore-feet have been detected, until some evidence appears that they were made by Birds. I have no doubt that Birds existed at this time, although at present the proof is wanting.

The principal genera of Triassic Reptiles known from osseous remains in this country are, *Amphisaurus* (*Megadactylus*), from the Connecticut Valley, *Bathygnathus*, from Prince Edward's Island, *Belodon* and *Clepsysaurus*. Other generic names which have been applied to foot-prints and to fragmentary remains, need not be here enumerated. A few remains of Reptiles have been found in undoubted Jurassic rocks of America, but they are not sufficiently well determined to be of service in this connection. Others have been reported from supposed Jurassic strata, which are now known to be Cretaceous. It will thus be seen that, although reptilian life was especially abundant during the Triassic and Jurassic periods, but few bones have been found. This is owing in part to the character of most of the rocks then formed, which were not well fitted for preserving such remains, although admirably adapted to retain foot-prints.

During the Cretaceous Period, Reptilian life in America attained its greatest development, and the sediments laid down in the open seas and estuaries were usually most favorable for the preservation of a faithful record of its various phases. Without such a perfect matrix as some of these deposits afford, many of the most interesting vertebrates recently brought to light from this formation would probably have remained unknown. The vast extent of these beds ensures, moreover, many future discoveries of interest.

In the lowest Cretaceous strata of the Rocky Mountain region, the Dakota group, part of which at least represents the Wealden of Europe, remains of *Chelonia*, or Turtles, Crocodiles, and Dinosaurs occur, the last being especially abundant. The *Chelonia*, although known from the Jurassic of Europe, here appear for the first time in American rocks. Some of the earliest forms are allied to the modern genus *Trionyx*. In the higher Cretaceous beds, some Chelonians of enormous size have been found. They belong to the genus *Atlantochelys*, which has the ribs separate, as in the existing *Sphargis*, and presents other embryonic characters. A few genera appear to be related to the modern genus *Chelone*. The remaining Cretaceous species were mostly of the Emydoid type; and others were related to *Chelydra*. The more important genera of Cretaceous Chelonians known from characteristic specimens are, *Atlantochelys* (*Protostega*), *Adocus*, *Bothremys*, *Compsemys*, *Plastomenus*, *Osteopygis*, *Propleura*, *Lytoloma*. and *Taphrosphys*. Most of these genera were represented by several species, and the individuals were numerous. No land Tortoises have as yet been found in this formation. In American Tertiary deposits, Chelonians are abundant, especially in the fresh-water beds. They all show near affinities with modern types, and most of them can be referred to existing genera. In the Tertiary lake-basins of the West, land Tortoises are very numerous, and with them are many fresh-water forms of *Trionyx* and allied genera.

A striking feature of the American Cretaceous fauna, as contrasted with that of Europe, is the almost entire absence in our strata of species of *Ichthyosaurus* and *Plesiosaurus*, which abound in many other regions, but here seem to be replaced by the Mosasaurs. A few fragmentary remains have indeed been referred to these genera, but the determination may fairly be questioned. This is more than true of the proposed new order *Streptosauria*, which was founded wholly on error. The order *Plesiosauria*, however, is well represented, but mainly by forms more nearly related to the genus *Pliosaurus* than to the type of the group. These were marine reptiles, all of large size, while some of them attained vast dimensions. So far as at present identified, they may be referred to the genera, *Cimoliosaurus*, *Discosaurus* (*Elasmosaurus*), and *Pliosaurus*. The number of species is comparatively few, and none are known above the Cretaceous. The important suggestion of Gegenbaur, that the *Halisauria*, which include the Plesiosaurs, branched off from the Fishes before the Amphibians, finds some support in American specimens recently discovered.

The Reptiles most characteristic of our American Cretaceous strata are the *Mosasauria*, a group with very few representatives in other parts of the world. In our Cretaceous seas, they ruled supreme, as their numbers, size, and carnivorous habits, enabled them to easily vanquish all rivals. Some were at least sixty feet in length, and the smallest ten or twelve. In the inland Cretaceous sea from which the Rocky Mountains were beginning to emerge, these ancient "Sea Serpents" abounded; and many were entombed in its muddy bottom. On one occasion, as I rode through a valley washed out of this old ocean bed, I saw no less than seven different skeletons of these monsters in sight at once. The Mosasaurs were essentially swimming Lizards, with four well developed paddles, and they had little affinity with modern serpents, to which they have been compared. The species are quite numerous, but they belong to comparatively few genera, of which *Mosasaurus*, *Tylosaurus*, *Lestosaurus* and *Edestosaurus*, have alone been identified with certainty. The genus *Mosasaurus* was first found in Europe. All the known species of the group are Cretaceous.

The *Crocodilia* are abundant in rocks of Cretaceous age in America, and two distinct types are represented. The older type, which is foreshadowed by *Belodon* of the Trias, has biconcave vertebræ, and shows marked affinities with the genus *Teleosaurus*, from the Jura of Europe. The best known genus is *Hyposaurus*, of which there are several species, all more or less resembling in form the modern Gavial of the Ganges. A peculiar intermediate form is seen in *Diplosaurus*, from the Wealden of the Rocky Mountains. The second type, which now makes its appearance for the first time, has procœlian vertebræ, and in other respects resembles existing Crocodiles. The genera described are *Bottosaurus*, *Holops* and *Thoracosaurus*, none of which, so far as known, pass above the

Cretaceous. Of *Crocodilia* with opisthocœlous vertebræ, America, so far as we know, has none. Specimens similar to those so termed in Europe, are not uncommon here, but they pertain to Dinosaurs.

In the Eocene fresh-water beds of the West, Crocodilians are especially abundant, and all, with the exception of *Limnosaurus*, belong apparently to the genus *Crocodilus*, although some species show certain points of resemblance to existing Alligators. The Miocene lake-basins of the same region contain no remains of Crocodiles, so far as known, and the Pliocene deposits have afforded only a single species. The Tertiary marine beds of the Atlantic Coast contain comparatively few Crocodilian remains, and all are of modern types; the genus *Gavialis* having one Eocene species, and the Alligator being represented only in the latest deposits.

It is worthy of special mention in this connection, that no true *Lacertilia*, or Lizards, and no *Ophidia*, or Serpents, have yet been detected in American Cretaceous beds; although their remains, if present, would hardly have escaped observation in the regions explored. The former will doubtless be found, as several species occur in the Mesozoic of Europe; and perhaps the latter, although the Ophidians are apparently a more modern type. In the Eocene lake-basins of Western America, remains of Lizards are very numerous, and indicate species much larger than any existing to-day. Some of these, the *Glyptosauridæ*, were protected by a highly ornamented bony coat of mail, and others were covered with scales, like recent Lizards. A few resembled, in their more important characters, the modern Iguana. The genera best represented in the Eocene, are, *Glyptosaurus*, *Iguanavus*, *Oreosaurus*, *Thinosaurus*, *Tinosaurus* and *Saniva*. Some of these genera appear to have continued into the Miocene, but here, as well as in the Pliocene, few remains of this group have been found. It is not improbable that some of our extinct Reptiles may prove to belong to *Rynchocephala*, but at present this is uncertain. The genus *Notosaurus*, from Brazil, has biconcave vertebræ, and some other characters which point to that group. No Dicynodonts or Theriodonts have as yet been found in this country.

The first American Serpents, so far as now known, appear in the Eocene, which contains also the oldest European species. On the Atlantic border, the genus *Titanophis* (*Dinophis*) is represented by several species of large size, one at least thirty feet in length, and all doubtless inhabitants of the sea. In the fresh-water Western Eocene, remains of snakes are abundant, but all are of moderate size. The largest of these were related to the modern Boa Constrictors. The genera described are *Boavus*, *Lithophis* and *Limnophis*. The Miocene and Pliocene

Snakes from the same region are known only from a few fragmentary remains.

The *Pterosauria*, or flying Lizards, are among the most interesting Reptiles of Mesozoic time, and many of them left their remains in the soft sediments of our inland Cretaceous sea. These were veritable Dragons, having a spread of wings of from ten to twenty-five feet. They differed essentially from the smaller Pterodactyls found in the old world, in the entire absence of teeth, showing in this respect a resemblance to modern birds; and they possess other distinctive characters. They have therefore been placed in a new order, *Pteranodontia*, from the typical genus *Pteranodon*, of which five species are known. The only other genus is *Nyctosaurus*, represented by a single species. All the specimens yet found are from essentially the same horizon, in the Chalk of Kansas. The reported discovery of remains of this order from older formations in this country is without foundation.

The strange Reptiles known as *Dinosauria*, which, as we have seen, were numerous during the deposition of our Triassic shales and sandstones, have not yet been found in American Jurassic, but were well represented here throughout the Cretaceous, and at its close became extinct. These animals possess a peculiar interest to the anatomist, since, although reptilian in all their main characters, they show clear affinities with the Birds, and have some features which may point to Mammals. The Cretaceous Dinosaurs were all of large size, and most of them walked on the hind feet alone, like modern Struthious birds. Two well marked types may be distinguished among the remains discovered in deposits of this age: the herbivorous forms, represented mainly by *Hadrosaurus*, a near ally of the *Iguanodon* of Europe; and their carnivorous enemies, of which *Dryptosaurus* (*Lælaps*) may be considered typical in this country, and *Megalosaurus* in Europe. Near the base of our Cretaceous formation, in beds which I regard as the equivalent of the European Wealden, the most gigantic forms of this order yet discovered have recently been brought to light. One of these monsters (*Titanosaurus montanus*), from Colorado, is by far the largest land animal yet discovered; its dimensions being greater than was supposed possible, in an animal that lived and moved upon the land. It was some fifty or sixty feet in length, and, when erect, at least thirty feet in height. It doubtless fed upon the foliage of the mountain forests, portions of which are preserved with its remains. With *Titanosaurus*, the bones of smaller Dinosaurs, one (*Nanosaurus*) not larger than a Cat, as well as those of Crocodiles and Turtles, are not uncommon. The recent discovery of these interesting remains, many and various, in strata that had long been pronounced by professional explorers barren of vertebrate fossils, should teach caution to those who decline to accept the imperfection of our knowledge to-day as a fair plea for the supposed absence of intermediate forms.

In the marine Cretaceous beds of the West, only a single Dinosaur (*Hadrosaurus agilis*), has been found, but in the higher fresh-water beds, which mark the close of this formation, their remains are numerous, and indicate several well marked species, if not genera. In the marine beds on the Atlantic Coast, the bones of Dinosaurs are frequently met with, and in the Upper Cretaceous Greensand of New Jersey, the type specimens of *Hadrosaurus* and *Dryptosaurus* were found. In Cretaceous fresh-water deposits on the coast of Brazil, remains of this order occur, but the specimens hitherto discovered are not sufficiently characteristic for accurate determination. This is unfortunately true of many Dinosaurian fossils from North America, but the great number of these Reptiles which lived here during the Cretaceous Period promises many future discoveries, and substantial additions to our present knowledge of the group.

The first appearance of Birds in America, according to our present knowledge, was during the Cretaceous Period, although many announcements have been made of their existence in preceding epochs. The evidence of their presence in the Trias, based on footprints and other impressions, is, at present, as we have seen, without value; although we may confidently await their discovery there, if not in older formations. *Archæopteryx*, from the European Jura, the oldest bird known, and now fortunately represented by more than a single specimen, clearly indicates a much higher antiquity for the class. The earliest American forms, at present known, are the *Odontornithes*, or Birds with teeth, which have been exhumed within the last few years, from the Chalk of Kansas. The two genera, *Hesperornis* and *Ichthyornis*, are types of distinct orders, and differ from each other and from *Archæopteryx* much more than do any existing birds among themselves; thus showing that Birds are now a closed type, and that the key to the history of the class must be sought for in the distant past.

In *Hesperornis*, we have a large aquatic bird, nearly six feet in length, with a strange combination of characters. The jaws are provided with teeth, set in grooves; the wings were rudimentary, and useless; while the legs were very similar to those of modern diving birds. This last feature was merely an adaptation, as the more important characters are Struthious, showing that *Hesperornis* was essentially a carnivorous swimming Ostrich. *Ichthyornis*, a small flying bird, was stranger still, as the teeth were in sockets; and the vertebræ biconcave, as in Fishes, and a few Reptiles. *Apatornis* and other allied forms occur in the same beds, and probably all were provided with teeth. It is strange that the companions of these ancient toothed Birds should have been Pterodactyls without teeth. In the later Cretaceous beds of the Atlantic Coast, various remains of aquatic Birds have been found, but all are apparently distinct from those of the West. The known genera of American Cretaceous birds are, *Apatornis*, *Baptornis*, *Graculavus*, *Hesperornis*, *Ichthyornis*, *Laornis*, *Lestornis*, *Palæotringa* and *Telmatornis*. These are represented by some twenty species. In Europe, but two species of Cretaceous birds are known, and both are based upon fragmentary specimens.

During the Tertiary period, Birds were numerous in this country, and all yet discovered appear to have belonged to modern types. The Eocene species described are mostly wading birds, but here, and in the later Tertiary deposits, some characteristic American forms make their appearance, strongly foreshadowing our present avian fauna. The extinct genera are the Eocene *Uintornis*, related to the Woodpeckers, and *Aletornis*, which includes several species of Waders. Among the existing genera found in our Tertiary beds are, *Aquila*, *Bubo*, *Meleagris*, *Grus*, *Graculus*, *Puffinus*, *and Catarractes*. The Great Auk (*Alca impennis*), which was once very abundant on our Northeast Coast, has become extinct within a few years.

In this brief summary of the past life of Reptiles and Birds in America, I have endeavored to exclude doubtful forms, and those very imperfectly known, preferring to present the conclusions reached by careful study, incomplete though they be, rather than weary you with a descriptive catalogue of all the fossils to which names have been applied. Even this condensed review can hardly fail to give you some conception of the wealth of our continent in the extinct forms of these groups, and thus to suggest what its actual life must have been.

Although the Trias offers at present the first unquestioned evidence of true Reptiles, we certainly should not be justified in supposing for a moment that older forms did not exist. So too in considering the different groups of Reptiles, which seem to make their first appearance at certain horizons, flourish for a time, and then decline, or disappear, every day brings evidence to show that they are but fragments of the unraveled strands which converge in the past to form the mystic cord uniting all life. If the attempt is made to follow back any single thread, and thus trace the lineage of a group, we are met by difficulties which the science of to-day can only partially remove. And yet the anatomist constantly sees in the fragments which he studies hints of relationship which are to him sure prophecies of future discoveries.

The genealogy of the *Chelonia* is at present unknown, and our American extinct forms, so far as we now have them, throw little light on their ancestry. This is essentially true, also, of our *Plesiosauria*, *Lacertilia* and *Ophidia*, although suggestive facts are not wanting to indicate possible lines of descent. With the *Crocodilia*, however, the case seems to be different, and Huxley has clearly pointed out the path for investigation. It is probable that material already exists in our museums for tracing the group through several important steps in its development. We have already seen that the modern procœlian type of this order goes back only to the Upper Cretaceous, while the *Belodonts*, of our Triassic rocks, with their biconcave vertebræ, are the oldest known Crocodilians. Our Jurassic, unfortunately, throws but little light on the intermediate forms, but we know that the line was continued, as it was in the old world through *Teleosaurus*. The beds of the Rocky Mountain Wealden have just furnished us with a genuine "missing link," a saurian (*Diplosaurus*) with essentially the skull and teeth of a modern Crocodile, and the vertebræ of its predecessor from the Trias. This peculiar reptile clearly represents an important stage in the progressive series, and evidently one soon after the separation of the Crocodile branch from the main stem. The modern Gavial type appears to have been developed about the same time, as the form was well established in the Upper Cretaceous genus, *Thoracosaurus*. The Teleosaurian group, with biconcave vertebræ, evidently the parent stock of Crocodilians, became extinct with *Hyposaurus* of the same horizon, leaving the Crocodile and Gavial, with their more perfect procœlian vertebræ, to contend for the supremacy. In the early Eocene, both of these types were abundant, but some of the Crocodiles possessed characters pointing towards the Alligators, which do not appear to have been completely differentiated until later.

Nothing is really known to-day of the earlier genealogy of the *Pterosauria*, but our American forms, without teeth, are clearly the last stage in their development before this peculiar group became extinct. The oldest European form, *Dimorphodon*, from the Lower Lias, had the entire jaws armed with teeth, and was provided with a long tail. The later genus *Pterodactylus* retained the teeth, but had essentially lost the tail; while *Ramphorhynchus* had retained the elongated tail, but had lost the teeth from the fore part of both jaws. In the genus *Pteranodon* from the American Cretaceous, the teeth are entirely absent, and the tail is a mere rudiment. In the gradual loss of the teeth and tail, these reptiles followed the same path as Birds, and might thus seem to approach them, as many have supposed. This resemblance, however, is only a superficial one, as a study of the more important characters of the Pterodactyls shows that they are an aberrant type of Reptiles, totally off the line through which the Birds were developed. The announcement made not long since in Europe, and accepted by some American authors, that the *Pterosauria*, in consequence of certain points in their structure, were essentially Birds, is directly disproved by American specimens, far more perfect than those on which the conclusion was based.

It is now generally admitted by biologists who have made a study of the vertebrates, that Birds have come down to us through the Dinosaurs, and the close affinity of the latter with recent Struthious Birds will hardly be questioned. The case amounts almost to a demonstration, if we compare, with Dinosaurs, their contemporaries, the Mesozoic Birds. The classes of Birds and Reptiles, as now living, are separated by a gulf so profound that a few years since it was cited by the opponents of evolution as the most important break in the animal series, and one which that doctrine could not bridge over. Since then, as Huxley has clearly shown, this gap has been virtually filled by the discovery of bird-like Reptiles and reptilian Birds. *Compsognathus* and *Archæopteryx* of the Old World, and *Ichthyornis* and *Hesperornis* of the New, are the stepping stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf, once thought impassable.

It remains now to consider the highest group of the Animal Kingdom, the class *Mammalia*, which includes Man. Of the existence of this class before the Trias we have no evidence, either in this country or in the Old World, and it is a significant fact that at essentially the same horizon in each hemisphere, similar low forms of Mammals make their appearance. Although only a few incomplete specimens have been discovered, they are characteristic and well preserved, and all are apparently Marsupials, the lowest Mammalian group which we know in this country, living or fossil. The American Triassic Mammals are known at present only from two small lower jaws, on which is based the genus *Dromotherium*, supposed to be related to the insect-eating *Myrmecobius*, now living in Australia.

Although the Jura of Europe has yielded other similar Mammals, we have as yet none of this class from that formation; while, from rocks of Cretaceous age, no Mammals are known in any part of the world. This is especially to be regretted, as it is evidently to the Cretaceous that we must look for the first representatives of many of our present groups of Mammals, as well as for indications of their more ancient lineage. That some discovery of this nature from the Cretaceous is near at hand, I cannot doubt, when I consider what the last few years have brought to light in the Eocene.

In the lowest Tertiary beds of this country, a rich Mammalian fauna suddenly makes its appearance, and from that time through the Age of Mammals to the present, America has been constantly occupied by this type of life in the greatest diversity of form. Fortunately, a nearly continuous record of this life, as preserved, is now accessible to us, and ensures great additions to our knowledge of the genealogy of Mammals, and perhaps the solution of more profound problems. Before proceeding to discuss in detail American fossil *Mammalia*, it is important to define the divisions of time indicated in our Tertiary and Post-Tertiary deposits, as these in many cases mark successive stages in the development of the mammals.

The boundary line between the Cretaceous and Tertiary in the region of the Rocky Mountains has been much in dispute during the last few years, mainly in consequence of the uncertain geological bearings of the fossil plants found near this horizon. The accompanying invertebrate fossils have thrown little light on the question, which is essentially, whether the great Lignite series of the West is uppermost Cretaceous, or lowest Eocene. The evidence of the numerous vertebrate remains is, in my judgment, decisive, and in favor of the former view.

This brings up an important point in Palæontology, one to which my attention was drawn several years since, namely: the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are most unsatisfactory witnesses; that invertebrate animals are much better; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization, or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy Reptiles or Birds, and the higher Mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves.

The evidence offered by fossil remains is, in the light of this law, conclusive, that the line, if line there be, separating our Cretaceous from the Tertiary, must at present be drawn where the Dinosaurs and other Mesozoic vertebrates disappear, and are replaced by the Mammals, henceforth the dominant type.

The Tertiary of Western America comprises the most extensive series of deposits of this age known to geologists, and important breaks in both the rocks and the fossils separate it into three well-marked divisions. These natural divisions are not the exact equivalents of the Eocene, Miocene, and Pliocene of Europe, although usually so considered, and known by the same names; but, in general, the fauna of each appears to be older than that of its corresponding representative in the other hemisphere; an important fact, not hitherto recognized. This partial resemblance of our extinct faunas to others in regions widely separated, where the formations are doubtless somewhat different in geological age, is precisely what we might expect, if, as was probable, the main migrations took place from this Continent. It is better at once to recognize this principle, rather than attempt to bring into exact parallelism, formations that were not strictly contemporaneous.

The freshwater Eocene deposits of our Western Territories, which are in the same region at least two miles in vertical thickness, may be separated into three distinct subdivisions. The lowest of these, resting unconformably on the Cretaceous, has been termed the Vermilion Creek, or Wahsatch, Group. It contains a well-marked mammalian fauna, the largest and most characteristic genus of which is the ungulate *Coryphodon*, and hence I have called these deposits the Coryphodon Beds. The middle Eocene strata, which have been termed the Green River and Bridger Series, may be designated as the Dinoceras Beds, as the gigantic animals of this order are only found here. The uppermost Eocene, or the Uintah Group, is especially well characterized by large mammals of the genus *Diplacodon*, and hence may be termed the Diplacodon Beds. The fauna of each of these three subdivisions was essentially distinct, and the fossil remains of each were entombed in different and successive ancient lakes. It is important to remember that these Eocene lake-basins all lie between the Rocky Mountains on the east and the Wahsatch Range on the west, or along the high central plateau of the Continent. As these mountain chains were elevated, the enclosed Cretaceous sea, cut off from the ocean, gradually freshened, and formed these extensive lakes, while the surrounding land was covered with a luxuriant tropical vegetation, and with many strange forms of animal life. As the upward movement of this region continued, these lake-basins, which for ages had been filling up, preserving in their sediments a faithful record of Eocene life-history, were slowly drained by the constant deepening of the outflowing rivers, and they have since remained essentially dry land.

The Miocene lake-basins are on the flanks of this region, where only land had been since the close of the Cretaceous. These basins contain three faunas, nearly or quite distinct. The lowest Miocene, which is only found east of the Rocky Mountains, alone contains the peculiar mammals known as the *Brontotheridæ*, and these deposits may be called the Brontotherium Beds. The strata next above, which represent the middle Miocene, have as their most characteristic fossil the genus *Oreodon*, and are known as the Oreodon Beds. The upper Miocene, which occurs in Oregon, is of great thickness, and from one of its most important fossils, *Miohippus*, may be designated as the Miohippus Series. The climate here during this period was warm temperate.

Above the Miocene, east of the Rocky Mountains and on the Pacific Coast, the Pliocene is well developed, and is rich in vertebrate remains. The strata rest unconformably on the Miocene, and there is a well-marked faunal change at this point, modern types now first making their appearance. For these reasons, we are justified in separating the Miocene from the Pliocene at this break; although in Europe where no marked break exists, the line seems to have been drawn at a somewhat higher horizon. Our Pliocene forms essentially a continuous series, although the upper beds may be distinguished from the lower by the presence of a true *Equus*, and some other existing genera. The Pliocene climate was similar to that of the Miocene. The Post-Pliocene beds contain many extinct mammals, and may thus be separated from recent deposits.

Returning now to our subject from this geological digression, —which will hardly be deemed unprofitable, since I have given you in few words the results of a great deal of hard mountain work,—let us consider the Tertiary mammals, as we know them from the remains already discovered, and attempt to trace the history of each order down to the present time. We have seen that a single small Marsupial, from the Trias, is the only mammal found in all the American rocks below the Eocene; and yet in beds of this age, immediately over the Chalk, fossil mammals of many different kinds abound.

The Marsupials, strange to say, are here few in number, and diminutive in size; and have as yet been identified only by fragmentary specimens, and most of them too imperfect for accurate description. In the higher Eocene deposits, this group is more abundant, but still represented by small animals, most of them insectivorous, or carnivorous in habit, like the existing Opossum. From the Miocene and Pliocene, no remains of Marsupials have been described. From the Post-Tertiary, only specimens nearly allied to those now living are known, and most of these were found in the caves of South America.

The Edentate Mammals are evidently an American type, and on this Continent attained a great development in numbers and size. No Eocene Edentates have been found here, and although their discovery in this formation has been announced, the identification proves to have been erroneous. In the Miocene of the Pacific Coast, a few fossils have been discovered which belong to animals of this group, and to the genus *Moropus*.

There are two species, one about as large as a Tapir, and the other nearly twice that size. This genus is the type of a distinct family, the *Moropodidæ.* In the lower Pliocene above, well preserved remains of Edentates of very large size have been found at several widely separated localities in Idaho and California. These belong to the genus *Morotherium*, of which two species are known. East of the Rocky Mountains, in the lower Pliocene of Nebraska, a large species apparently of the genus *Moropus* has been discovered. The horizon of these later fossils corresponds nearly with beds in Europe that have been called Miocene. In the Post-Pliocene of North America, gigantic Edentates were very numerous and widely distributed, but all disappeared with the close of that period. These forms were essentially huge Sloths, and the more important genera were *Megatherium*, *Mylodon* and *Megalonyx.* The genera *Megalocnus* and *Myomorphus* have been found only in Cuba.

In South America during the Pliocene or Post-Pliocene, enormous Edentates were still more abundant, and their remains are usually in such perfect preservation as to suggest a very recent period for their extinction. The Sloth tribe is represented by the huge *Mylodon*, *Megatherium*, *Megalonyx*, *Cœlodon*, *Ochotherium*, *Gnathopis*, *Lestodon*, *Scelidotherium*, and *Sphœnodon;* and among the Armadilloes were *Chlamydotherium*, *Eurydon*, *Glyptodon*, *Heterodon*, *Pachytherium* and *Schistopleurum.* *Glossotherium*, another extinct genus, is supposed to be allied to the Ant-eaters.

It is frequently asserted, and very generally believed, that the large number of huge *Edentata* which lived in North America during the Post-Pliocene, were the results of an extensive migration from South America soon after the elevation of the Isthmus of Panama, near the close of the Tertiary. No conclusive proof of such migration has been offered, and the evidence, it seems to me, so far as we now have it, is directly opposed to this view. No undoubted Tertiary Edentates have yet been discovered in South America, while we have at least two species in our Miocene, and during the deposition of our lower Pliocene, large individuals of this group were not uncommon as far north as the forty-third parallel of latitude, on both sides of the Rocky Mountains. In view of these facts, and others which I shall lay before you, it seems more natural to conclude from our present knowledge, that the migration, which no doubt took place, was from north to south. The Edentates finding thus in South America a congenial home flourished greatly for a time, and although the larger forms are now all extinct, diminutive representatives of the group still inhabit the same region.

The *Cetacea* first appear in the Eocene, as in Europe, and are comparatively abundant in deposits of this age on the Atlantic Coast. The most interesting remains of this order, yet found, belong to the *Zeuglodontidæ*, which are carnivorous whales, and the only animals of the order with teeth implanted by two roots. The principal genera of this family are *Zeuglodon* and *Squalodon*, the former genus being represented by gigantic forms, some of which were seventy feet in length. The genus *Saurocetes*, which includes some small animals of this group, has been found in South America. The Dolphin family (*Delphinidæ*) are well represented in the Miocene, both on the Atlantic and Pacific Coast. The best known genus is *Priscodelphinus*, of which several species have been described. Several other generic names which have been applied to fragments need not here be enumerated. In none of the Tertiary species of this family were the cervical vertebræ ankylosed. The Sperm Whales (*Catodontidæ*) were also abundant throughout the Tertiary, and with them in the earlier beds, various Ziphioid forms have been found. The toothless *Balænidæ* are only known with certainty as fossils from the later Tertiary and more recent deposits.

The Sirenians, which appear first in the Eocene of the Old World, occur in the Miocene of our Eastern Coast, and throughout the later Tertiary. The specimens described have all been referred to the genus *Manatus*, and seem closely related to our living species. In the Tertiary of Jamaica, a skull has been found which indicates a new genus, *Prorastomus*, also allied to the existing Manatee. The genus *Rhytina*, once abundant on our Northwest Coast, has recently become extinct.

The Ungulates are the most abundant Mammals in the Tertiary, and the most important; since they include a great variety of types, some of which we can trace through their various changes down to the modified forms that represent them to-day. Of the various divisions in this comprehensive group, the Perissodactyle, or odd-toed Ungulates, are evidently the oldest, and throughout the Eocene are the prevailing forms. Although all of the Perissodactyles of the earlier Tertiary are more or less generalized, they are still quite distinct from the Artiodactyles, even at the base of the Eocene. One family, however, the *Coryphodontidæ*, which is well represented at this horizon, both in America and Europe, although essentially *Perissodactyle*, possesses some characters which point to a primitive Ungulate type from which the present orders have been evolved. Among these characters are the diminutive brain, which in size and form approaches that of the Reptiles, and also the five-toed feet from which all the various forms of the mammalian foot have been derived. Of this family, only a single genus, *Coryphodon* (*Bathmodon*), is known, but there were several distinct species. They were the largest mammals of the lower Eocene, some exceeding in size the existing Tapirs.

In the middle Eocene, West of the Rocky Mountains, a remarkable group of ungulates makes its appearance. These animals nearly equaled the Elephant in size, but had shorter limbs. The skull was armed with two or three pairs of horn-cores, and with enormous canine tusks. The brain was proportionally smaller than in any other land mammal. The feet had five toes, and resembled in their general structure those of *Coryphodon*, thus indicating some affinity with that genus. These mammals resemble in some respects the Perissodactyles, and in others the Proboscidians, yet differ so widely from any known Ungulates, recent or fossil, that they must be regarded as forming a distinct order, the *Dinocerata*. Only three genera are known, *Dinoceras*, *Tinoceras* and *Uintatherium*, but quite a number of species have been described. During the later part of the middle Eocene, these animals were very abundant for a short time, and then became extinct, leaving apparently no successors, unless possibly we have in the Proboscidians their much modified descendants. Their genetic connection with the Coryphodonts is much more probable, in view of what we now know of the two groups.

Besides these peculiar Mammals, which are extinct, and mainly of interest to the Biologist, there were others in the early Tertiary which remind us of those at present living around us. When a student in Germany some twelve years ago, I heard a world-renowned Professor of Zöology gravely inform his pupils that the Horse was a gift of the Old World to the New, and was entirely unknown in America until introduced by the Spaniards. After the lecture, I asked him whether no earlier remains of horses had been found on this Continent, and was told in reply that the reports to that effect were too unsatisfactory to be presented as facts in science. This remark led me, on my return, to examine the subject myself, and I have since unearthed, with my own hands, not less than thirty distinct species of the horse tribe, in the Tertiary deposits of the West alone; and it is now, I think generally admitted that America is, after all, the true home of the Horse.

I can offer you no better illustration than this of the advance vertebrate palæontology has made during the last decade, or of the important contributions to this progress which our Rocky Mountain region has supplied.

The oldest representative of the horse. at present known, is the diminutive *Eohippus* from the lower Eocene. Several species have been found, all about the size of a fox. Like most of the early mammals, these Ungulates had forty-four teeth, the molars with short crowns, and quite distinct in form from the premolars. The ulna and the fibula were entire and distinct, and there were four well developed toes and a rudiment of another on the fore feet, and three toes behind. In the structure of the feet, and in the teeth, the *Eohippus* indicates unmistakably that the direct ancestral line to the modern horse has already separated from the other Perissodactyles. In the next higher division of the Eocene, another genus (*Orohippus*) makes its appearance, replacing *Eohippus*, and showing a greater, although still distant, resemblance to the Equine type. The rudimentary first digit of the fore foot has disappeared, and the last premolar has gone over to the molar series. *Orohippus* was but little larger than *Eohippus*, and in most other respects very similar. Several species have been found in the same horizon with *Dinoceras*, and others lived during the upper Eocene with *Diplacodon*, but none later.

Near the base of the Miocene, in the Brontotherium beds, we find a third closely allied genus, *Mesohippus*, which is about as large as a sheep, and one stage nearer the horse. There are only three toes and a rudimentary splint bone on the fore feet, and three toes behind. Two of the premolar teeth are quite like the molars. The ulna is no longer distinct, or the fibula entire, and other characters show clearly that the transition is advancing. In the upper Miocene, *Mesohippus* is not found, but in its place a fourth form, *Miohippus*, continues the line. This genus is near the *Anchitherium* of Europe, but presents several important differences. The three toes in each foot are more nearly of a size, and a rudiment of the fifth metacarpal bone is retained. All the known species of this genus are larger than those of *Mesohippus*, and none pass above the Miocene.

The genus *Protohippus* of the lower Pliocene, is yet more equine, and some of its species equaled the ass in size. There are still three toes on each foot, but only the middle one, corresponding to the single toe of the horse, comes to the ground. This genus resembles most nearly the *Hipparion* of Europe. In the Pliocene, we have the last stage of the series before reaching the horse, in the genus *Pliohippus*, which has lost the small hooflets, and in other respects is very equine. Only in the upper Pliocene, does the true *Equus* appear, and complete the genealogy of the Horse, which in the Post-Tertiary roamed over the whole of North and South America, and soon after became extinct. This occurred long before the discovery of the Continent by Europeans, and no satisfactory reason for the extinction has yet been given. Besides the characters I have mentioned, there are many others, in the skeleton, skull, teeth, and brain of the forty or more intermediate species, which show that the transition from the Eocene *Eohippus* to the modern *Equus*, has taken place in the order indicated, and I believe the specimens now at New Haven will demonstrate the fact to any anatomist. They certainly carried prompt conviction to the first of anatomists, who was the honored guest of the Association a year ago, whose genius had already indicated the later genealogy of the horse in Europe, and whose own researches so well qualified him to appreciate the evidence here laid before him. Did time permit, I might give you at least a probable explanation of this marvellous change, but justice to the comrades of the horse in his long struggle for existence demands that some notice of their efforts should be placed on record.

Beside the Horse and his congeners, the only existing Perissodactyles are the Rhinoceros and the Tapir. The last is the oldest type, but the Rhinoceros had near allies throughout the Tertiary; and, in view of the continuity of the equine line, it is well worth while to attempt to trace his pedigree. At the bottom of the Eocene, in our Western lake-basins, the tapiroid genus *Helaletes* is found, represented by numerous small mammals hardly larger than the diminutive horses of that day. In the following epoch of the Eocene, the closely allied *Hyrachyus* was one of the most abundant animals. This genus was nearly related to the *Lophiodon* of Europe, and in its teeth and skeleton strongly resembled the living Tapir; whose ancestry, to this point, seems to coincide with that of the Rhinoceros we are considering. Strangely enough, the Rhinoceros line, before it becomes distinct, separates into two branches. In the upper part of the Dinoceras Beds, we have the genus *Colonoceras*, which is really a *Hyrachyus* with a transverse pair of very rudimentary horn-cores on the nasal bones. In the lower Miocene west of the Rocky Mountains, this line seems to pass on through the genus *Diceratherium*, and in the higher Miocene this genus is well represented. Some of the species nearly equaled in size the existing Rhinoceros, which *Diceratherium* strongly resembled. The main difference between them is a most interesting one. The rudimentary horn-cores on the nasals, seen in *Colonoceras*, are in *Diceratherium* developed into strong bony supports for horns, which were placed transversely, as in the Ruminants, and not on the median line, as in all existing forms of Rhinoceros. In the Pliocene of the Pacific Coast, a large Rhinoceros has been discovered, which may be a descendant of *Diceratherium*, but as the nasal bones have not been found, we must wait for further evidence on this point. Returning now to the other branch of the Rhinoceros group, which left their remains mainly East of the Rocky Mountains, we find that all the known forms are hornless. The upper Eocene genus *Amynodon* is the oldest known Rhinoceros, and by far the most generalized of the family.

The premolars are all unlike the molars, the four canines are of large size, but the inner incisor in each jaw is lost in the fully adult animal. The nasals were without horns. There were four toes in front, and three behind. The genus *Hyracodon*, of the Miocene, which is essentially a Rhinoceros, has a full set of incisor and canine teeth; and the molars are so nearly like those of its predecessor *Hyrachyus*, that no one will question the transformation of the older into the newer type. *Hyracodon*, however, appears to be off the true line, for it has but three toes in front. In the higher Miocene beds, and possibly with *Hyracodon*, occurs a larger Rhinoceros, which has been referred to the genus *Aceratherium*. This form has lost the canine and one incisor above, and two incisors below. In the Pliocene are several species closely related, and of large size. Above the Pliocene in America, no vestiges of the Rhinoceros have been found, and our American forms doubtless became extinct at the close of this period.

The Tapir is clearly an old American type, and we have seen that, in the Eocene, the genera *Helaletes* and *Hyrachyus* were so strongly tapiroid in their principal characters, that the main line of descent probably passed through them. It is remarkable that the Miocene of the West, so greatly developed as it is on both sides of the Rocky Mountains, should have yielded but a few fragments of tapiroid mammals, and the same is true of the Pliocene of that region. In the Miocene of the Atlantic Coast, too, only a few imperfect specimens have been found. These forms all apparently belong to the genus *Tapiravus*, although most of them have been referred to *Lophiodon*, a lower Eocene type. In the Post-Tertiary, a true *Tapirus* was abundant, and its remains have been found in various parts of North America. The line of descent, although indistinct through the middle and upper Tertiary, was doubtless continuous in America, and several species exist at present, from Mexico southward. It is worthy of notice that the species North of the Isthmus of Panama appear all to be generically distinct from those of South America.

In addition to these three Perissodactyle types which, as the fittest, have alone survived, and whose lineage I have endeavored to trace, there were many others in early Tertiary times. Some of these disappeared with the close of the Eocene, while others continued, and assumed strange specialized shapes in the Miocene, before their decline and extinction. One series of the latter deserves especial mention, as it includes one of the most interesting families of our extinct animals. Among the large mammals in the lower Eocene is *Limnohyus*, a true Perissodactyle, but only known here from fragments of the skeleton. In the next higher beds, this genus is well represented, and with it is found a nearly allied form, *Palæosyops*. In the upper Eocene, both have left the field, and the genus *Diplacodon*, a very near relative, holds the supremacy. The line seems clear through these three genera, but on crossing the break into the Miocene, we have, apparently as next of kin, the huge *Brontotheridæ*. These strange beasts show in their dentition and some other characters the same transition steps beyond *Diplacodon*, which that genus had made beyond *Palæosyops*. The *Brontotheridæ* were nearly as large as the Elephant, but had much shorter limbs. The skull was elongated, and had a transverse pair of large horn-cores on the maxillaries, in front of the orbits, like the middle pair in *Dinoceras*. There were four toes in front, and three behind, and the feet were similar to those of the Rhinoceros. There are four genera in this group, *Brontotherium; Diconodon; Menodus* (*Titanotherium*); and *Megacerops*, which have been found only in the lowest Miocene, east of the Rocky Mountains.

In the higher Miocene beds of Oregon, an allied genus, *Chalicotherium*, makes its appearance. It is one stage further on in the transition, and perhaps a descendant of the *Brontotheridæ;* but here, so far as now known, the line disappears. It is a suggestive fact, that this genus has now been found in Western America, China, India, Greece, Germany and France, indicating thus, as I believe, the path by which many of our ancient mammals helped to people the so-called Old World.

The Artiodactyles, or even-toed Ungulates, are the most abundant of the larger mammals now living; and the group dates back at least to the lowest Eocene. Of the two well marked divisions of this order, the Bunodonts and the Selenodonts, as happily defined by Kowalevsky, the former is the older type, which must have separated from the Perissodactyle line after the latter had become differentiated from the primitive Ungulate. In the Coryphodon Beds of New Mexico, occurs the oldest Artiodactyle yet found, but it is at present known only from fragmentary specimens. These remains are clearly Suilline in character, and belong to the genus *Eohyus*. In the beds above, and possibly even in the same horizon, the genus *Helohyus* is not uncommon, and several species are known. The molar teeth of this genus are very similar to those of the Eocene *Hyracotherium*, of Europe, which is supposed to be a Perissodactyle, while *Helohyus* certainly is not, but apparently a true lineal ancestor of the existing pigs. In every vigorous primitive type which was destined to survive many geological changes, there seems to have been a tendency to throw off lateral branches, which became highly specialized and soon died out, because they are unable to adapt themselves to new conditions. The narrow path of the persistent Suilline type, throughout the whole Tertiary, is strown with the remains of such ambitious offshoots, while the typical pig, with an obstinacy never lost, has held on in spite of Catastrophes and Evolution, and still lives in America to-day. In the lower Eocene, we have in the genus *Parahyus* apparently one of these short-lived, specialized branches. It attained a much larger size than the true lineal forms, and the number of its teeth was reduced. In the Dinoceras Beds, or middle Eocene, we have still, on or near the true line, *Helohyus*, which is the last of the series known from the American Eocene. All these early Suillines, with the possible exception of *Parahyus*, appear to have had at least four toes, all of usable size.

In the lower Miocene, we find the genus *Perchœrus*, seemingly a true Suilline, and with it remains of a larger form, *Elotherium*, are abundant. The latter genus occurs in Europe in nearly the same horizon, and the specimens known from each Continent agree closely in general characters. The name *Pelonax* has been applied erroneously to some of the American forms; but the specimens on which it was based clearly belong to *Elotherium*. This genus affords another example of the aberrant Suilline offshoots, already mentioned. Some of the species were nearly as large as a Rhinoceros, and in all there were but two serviceable toes; the outer digits, seen in living animals of this group, being represented only by small rudiments concealed beneath the skin. In the upper Miocene of Oregon, Suillines are abundant, and almost all belong to the genus *Thinohyus*, a near ally of the modern Peccary (*Dicotyles*), but having a greater number of teeth, and a few other distinguishing features. In the Pliocene, Suillines are still numerous, and all the American forms yet discovered are closely related to *Dicotyles*. The genus *Platygonus* is represented by several species, one of which was very abundant in the Post-Tertiary of North America, and is apparently the last example of a side branch, before the American Suillines culminate in existing Peccaries. The feet in this species are more specialized than in the living forms, and approach some of the peculiar features of the ruminants; as for example a strong tendency to coalescence in the metapodial bones. The genus *Platygonus* became extinct in the Post-Tertiary, and the later and existing species are all true Peccaries. No authenticated remains of the genera *Sus*, *Porcus*, *Phacochœrus*, or the allied *Hippopotamus*, the Old World Suillines, have been found in America, although several announcements to that effect have been made.

In the series of generic forms between the lower Eocene *Eohyus* and the existing *Dicotyles*, which I have very briefly discussed, we have apparently the ancestral line ending in the typical American Suillines. Although the demonstration is not yet as complete as in the lineage of the Horse, this is not owing to want of material, but rather to the fact that the actual changes which transformed the early Tertiary pig into the modern Peccary were comparatively slight, so far as they are indicated in the skeletons preserved, while the lateral branches were so numerous as to confuse the line. It is clear, however, that from the close of the Cretaceous to the Post-Tertiary, the Bunodont Artiodactyles were especially abundant on this Continent, and only recently have approached extinction.

The Selenodont division of the Artiodactyles is a more interesting group and, so far as we now know, makes its first appearance in the upper Eocene of the West, although forms, apparently transitional, between it and the Bunodonts occur in the Dinoceras Beds, or middle Eocene. These belong to the genus *Homacodon*, which is very nearly allied to *Helohyus* and but a single step away from this genus toward the Selenodonts. By a fortunate discovery, a nearly complete skeleton of this rare intermediate form has been brought to light, and we are thus enabled to define its characters. Several species of *Homacodon* are known, all of small size. This primitive Selenodont had forty-four teeth, which formed a nearly continuous series.

The molar teeth are very similar to those of *Helohyus*, but the cones on the crowns have become partially triangular in outline, so that when worn, the Selenodont pattern is clearly recognizable. The first and second upper molars, moreover, have three distinct posterior cusps, and two in front; a peculiar feature, which is seen also in the European genera *Dichobune* and *Cainotherium*. There were four toes on each foot, and the metapodial bones were distinct. The type species of this genus was about as large as a cat. With *Helohyus*, this genus forms a well marked family, the *Helohyidæ*.

In the *Diplacodon* horizon of the upper Eocene, the Selenodont dentition is no longer doubtful, as it is seen in most of the *Artiodactyla* yet found in these beds. These animals are all small, and belong to at least three distinct genera. One of these, *Eomeryx*, closely resembles *Homacodon* in most of its skeleton, and has four toes, but its teeth show well marked crescents, and a partial transition to the teeth of *Hyopotamus*, from the Eocene of Europe. With this genus, is another (*Parameryx*), also closely allied to *Homacodon*, but apparently a straggler from the true line, as it has but three toes behind. The most pronounced Selenodont in the upper Eocene is the *Oromeryx*, which genus appears to be allied to the existing Deer family, or *Cervidæ*, and if so is the oldest known representative of the group. These facts are important, as it has been supposed, until very recently, that our Eocene contained no even-hoofed mammals.

In the lowest Miocene of the West, no true crescent-toothed *Artiodactyla* have as yet been identified, with the exception of a single species of *Hyopotamus;* but in the overlying beds of the middle Miocene, remains of the *Oreodontidæ* occur in such vast numbers as to indicate that these animals must have lived in large herds around the borders of the lake-basins in which their remains have been entombed. These basins are now the denuded deserts so well termed *Mauvaises Terres* by the early French trappers. The least specialized, and apparently the oldest, genus of this group is *Agriochœrus*, which so nearly resembles the older *Hyopotamus*, and the still more ancient *Eomeryx*, that we can hardly doubt that they all belonged to the same ancestral line. The typical Oreodonts are the genera *Oreodon* and *Eporeodon*, which have been aptly termed by Leidy, ruminating hogs. They had forty-four teeth, and four well developed toes on each foot. The true Oreodons, which were most numerous east of the Rocky Mountains, were about as large as the existing Peccary, while *Eporeodon*, which was nearly twice this size, was very abundant in the Miocene of the Pacific slope.

In the succeeding Pliocene formation, on each side of the Rocky Mountains, the genus *Merychyus* is one of the prevailing forms, and continues the line on from the Miocene, where the true Oreodons became extinct. Beyond this, we have the genus *Merycochœrus*, which is so nearly allied to the last, that they would be united by many naturalists. With the close of the Pliocene, this series of peculiar ruminants abruptly terminates, no member surviving until the Post-Tertiary, so far as known.

A most interesting line, that leading to the Camels and Llamas, separates from the primitive Selenodont branch in the Eocene, probably through the genus *Parameryx*. In the Miocene, we find in *Pœbrotherium* and some nearly allied forms unmistakable indications that the Cameloid type of ruminant had already become partially specialized, although there is a complete series of incisor teeth, and the metapodial bones are distinct. In the Pliocene, the Camel tribe was, next to the Horses, the most abundant of the larger mammals. The line is continued through the genus *Procamelus*, and perhaps others, and in this formation the incisors first begin to diminish, and the metapodials to unite. In the Post-Tertiary we have a true *Auchenia*, represented by several species, and others in South America, where the Alpacas and Llamas still survive. From the Eocene almost to the present time, North America has been the home of vast numbers of the *Camelidæ*, and there can be little doubt that they originated here, and migrated to the Old World.

Returning once more to the upper Eocene, we find another line of descent starting from *Oromeryx*, which, as we have seen, had apparently then just become differentiated from the older Bunodont type. Throughout the middle and upper Miocene, this line is carried forward by the genus *Leptomeryx* and its near allies, which resemble so strongly the Pliocene *Cervidæ* that they may fairly be regarded as their probable progenitors. Possibly some of these forms may be related to the *Tragulidæ*, but at present the evidence is against it.

The Deer family has representatives in the upper Miocene of Europe, which contains fossils strongly resembling the fauna of our lower Pliocene, a fact always to be borne in mind in comparing the horizon of any group in the two continents. Several species of *Cervidæ*, belonging to the genus *Cosoryx*, are known from the lower Pliocene of the West, and all have very small antlers, divided into a single pair of tynes. The statement recently published, that most of these antlers had been broken during the life of the animals, is unsupported by any evidence, and is erroneous. These primitive Deer do not have the orbit closed behind, and they have all the four metapodial bones entire, although the second and fifth are very slender. In the upper Pliocene, a true *Cervus* of large size has been discovered. In the Post-Tertiary, *Cervus*, *Alces*, and *Tarandus* have been met with, the latter far south of its present range. In the caves of South America, remains of *Cervus* have been found, and also two species of Antelopes, one referred to a new genus, *Leptotherium*.

The Hollow-horned Ruminants, in this country, appear to date back no further than to the lower Pliocene, and here only two species of *Bison* have as yet been discovered. In the Post-Tertiary this genus was represented by numerous individuals and several species, some of large size. The Musk Ox (*Ovibos*) was not uncommon during some parts of this epoch, and its remains are widely distributed.

No authentic fossil remains of true Sheep, Goats, or Giraffes have as yet been found on this continent.

The Proboscideans, which are now separated from the typical Ungulates as a distinct order, make their first appearance in North America in the lower Pliocene, where several species of *Mastodon* have been found. This genus occurs, also, in the upper Pliocene, and in the Post-Tertiary; although some of the remains attributed to the latter are undoubtedly older. The Pliocene species all have a band of enamel on the tusks, and some other peculiarities observed in the oldest Mastodons of Europe, which are from essentially the same horizon. Two species of this genus have been found in South America, in connection with the remains of extinct Llamas and Horses. The genus *Elephas* is a later form, and has not yet been identified in this country below the upper Pliocene, where one gigantic species was abundant. In the Post-Pliocene, remains of this genus are numerous. The hairy Mammoth of the Old World (*Elephas primigenius*) was once abundant in Alaska, and great numbers of its bones are now preserved in the frozen cliffs of that region. This species does not appear to have extended east of the Rocky Mountains, or south of the Columbia River, but was replaced there by the American Elephant, which preferred a milder climate. Remains of the latter have been met with in Canada, throughout the United States, and in Mexico. The last of the American Mastodons and Elephants became extinct in the Post-Tertiary.

The order *Toxodontia* includes two very peculiar genera, *Toxodon* and *Nesodon*, which have been found in the Post-Tertiary deposits of South America. These animals were of huge size, and possessed such mixed characters that their affinities are a matter of considerable doubt. They are thought to be related to the Ungulates, Rodents, and Edentates, but as the feet are unknown, this cannot at present be decided.

Macrauchenia and *Homalodontotherium* are two other peculiar genera from South America, now extinct, the exact affinities of which are uncertain. *Anoplotherium* and *Palæotherium*, so abundant in Europe, have not been found in our North American Tertiary deposits, although reported from South America.

Perhaps the most remarkable mammals yet found in America are the *Tillodontia*, which are comparatively abundant in the lower and middle Eocene. These animals seem to combine the characters of several different groups, viz: the Carnivores, Ungulates, and Rodents. In the genus *Tillotherium*, the type of the order, and of the family *Tillotheridæ*, the skull resembles that of the Bears; the molar teeth are of the ungulate type; while the large incisors are very similar to those of Rodents. The skeleton resembles that of the Carnivores, but the scaphoid and lunar bones are distinct, and there is a third trochanter on the femur. The feet are plantigrade, and each had five digits, all with long pointed claws. In the allied genus *Stylinodon*, which belongs to a distinct family, the *Stylinodontidæ*, all the teeth were rootless. Some of these animals were as large as a Tapir. The genus *Dryptodon* has been found only in the *Coryphodon* beds of New Mexico, while *Tillotherium* and *Stylinodon* occur in the middle Eocene of Wyoming. *Anchippodus* probably belongs to this group, which may perhaps include some other forms that have been named from fragmentary specimens.

The Rodents are an ancient type, and their remains are not unfrequently disinterred in the strata of our lowest fresh-water

Eocene. The earliest known forms are apparently all related to the Squirrels, and the most common genus is *Sciuravus*, which continued throughout the Eocene. A nearly allied form, which may prove to be the same, is *Paramys*, the species of which are larger than those of the older type. In the Dinoceras beds, the genus *Colonomys* is found, and the specimens preserved point to the *Muridæ*, as the nearest living allies. A peculiar genus, *Apatemys*, which also occurs in the middle Eocene, has gliriform incisors, but the molars resemble those of Insectivores. All the Eocene Rodents are of small size, the largest being about as large as a rabbit.

In the middle and upper Miocene lake-basins of the West, Rodents abound, but all are of moderate size. The Hares first appear in the Oreodon beds, and continue in considerable numbers through the rest of the Tertiary and Post-Tertiary to the present day. In these beds, the most common forms belong to the *Leporidæ*, and mainly to the genus *Palæolagus*. The Squirrel family is represented by *Ischyromys*, the *Muridæ* by the genus *Eumys*, and the Beavers by *Palæocastor*. In the upper Miocene of Oregon, most of the same genera are found, and with them some peculiar forms, very unlike anything now living. One of these is the genus *Allomys*, possibly related to the flying Squirrels, but having molar teeth somewhat like those of the Ungulates. In the Pliocene, east and west of the Rocky Mountains, Rodents continue abundant, but most of them belong to existing genera. Among these are *Castor*, *Hystrix*, *Cynomys*, *Geomys*, *Lepus* and *Hesperomys*. In the Post-Tertiary, the gigantic beaver, *Castoroides*, was abundant throughout most of North America. *Hydrochærus* has been found in South Carolina. In the caves of the island of Anguilla, in the West Indies, remains of large extinct Rodents belonging to the *Chinchillidæ* have been discovered.

The early Tertiary Rodents known from South America are the genera *Megamys*, *Theridromys*, and a large species referred to *Arvicola*. In Brazil, the Pliocene Rodents found are referred to the existing genera *Cavia*, *Kerodon*, *Lagostomus*, *Ctenomys*, *Hesperomys*, *Oxymycterus*, *Arvicola* and *Lepus*. A new genus, *Cardiodus*, described from this horizon, is a true Rodent, but the peculiar *Typotherium*, which has been referred to this order by some authorities, has perhaps other affinities. In the Post-Tertiary, the Rodents were very abundant in South America, as they are at present. The species are in most instances distinct from those now living, but the genera are nearly the same. The *Caviidæ* were especially numerous. *Cercolabes*, *Myopotamus*, and *Lagostomus* are also found, and two extinct genera, *Phyllomys* and *Lonchophorus*.

The *Cheiroptera*, or Bats, have not been found in this country below the middle Eocene, where two extinct genera, *Nyctilestes* and *Nyctitherium*, are each represented by numerous remains. These fossils all belong to small animals, and, so far as they have been investigated, show no characters of more than generic importance to distinguish them from the Bats of to-day. No other members of this group are known from our Tertiary. In the Post-Tertiary, no extinct species of Bats have been found in North America, but from the caves of Brazil quite a number have been reported. These all belong to genera still living in South America, and most of them to the family *Phyllostomidæ*.

The Insectivores date back, in this country, at least to the middle Eocene. Here numerous remains occur, which have been described as belonging to this order, although it is possible that some of them were insect-eating Marsupials. The best known genera are, *Hemiacodon*, *Centetodon*, *Talpavus*, and *Entomacodon;* all represented by animals of small size. In the Miocene, the bones of Insectivores are comparatively abundant, and the genera best determined are *Ictops* and *Leptictis*. A few specimens only have been found in the Pliocene and Post-Pliocene, most of them related to the Moles. No extinct Insectivores are known from South America, and no member of the group exists there at present.

The *Carnivora*, or true flesh-eating animals, are an old type, well represented in the Eocene, and, as might be expected, these early forms are much less specialized than the living species. In the Coryphodon beds, the genus *Limnocyon*, allied to the *Pterodon* of the European Eocene, is abundant. Another genus, apparently distinct, is *Prototomus*, and several others have been named from fragmentary fossils. In the middle Eocene, Carnivores were still more numerous, and many genera have been discovered. One of these, *Limnofelis*, was nearly as large as a lion, and apparently allied to the cats, although the typical *Felidæ* seem not yet to have been differentiated. Another Carnivore of nearly equal size was *Orocyon*, which had short massive jaws and broad teeth. *Dromocyon* and *Mesonyx* were large animals, allied to *Hyænodon*. The teeth were narrow, and the jaws long and slender. Among the smaller Carnivores were, *Vulpavus*, *Viverravus*, *Sinopa*, *Thinocyon*, and *Ziphacodon*.

In our Western Miocene, Carnivores are abundant, and make an approach to modern types. The *Felidæ* are well represented, the most interesting genus being *Machairodus*, which is not uncommon in the Oreodon beds on both sides of the Rocky Mountains. An allied genus is *Dinictis*, and several smaller Cats are known from about the same horizon. The *Canidæ* are represented by *Amphicyon*, a European genus, and by several species of *Canis*, or a very nearly allied form. The peculiar genus *Hyænodon*, found also in Europe, and the type of a distinct family, is abundant in the Miocene east of the Rocky Mountains, but has not yet been found on the Pacific Coast. In the Pliocene of both regions, the *Canidæ* are numerous, and all apparently belong to the existing genus *Canis*. The genus *Machairodus* is still the dominant form of the Cats, which are abundant, and for the most part belong to the genus *Felis*. The extinct *Leptarctus* is supposed to belong to the *Ursidæ*, and if so, is the oldest American representative of this family. In the Post-Pliocene, the extinct *Felidæ* include species nearly as large as a lion, and smaller forms very similar to those still living. Bears, Raccoons and Weasels have also been found.

In the Pliocene of South America, *Machairodus* represents the *Felidæ*, while the genera *Arctotherium* and *Hyænarctus* belong to the Bear family. Species of *Mustela* and *Canis* have also been found. In the caves of Brazil, the fauna of which is regarded as Post-Pliocene, one species of *Machairodus* is known, and one of *Synœlurus*. *Canis* and *Icticyon*, still living in Brazil, and the extinct genus *Speothos*, represent the *Canidæ*. *Mephitis* and *Galictis*, among the Weasels, were also present, and with them species of *Nasua* and *Arctotherium*.

We come now to the highest group of Mammals, the Primates, which includes the Lemurs, the Apes, and Man. This order has a great antiquity, and even at the base of the Eocene we find it represented by several genera belonging to the lower forms of the group. In considering these interesting fossils, it is important to have in mind that the Lemurs, which are usually regarded as Primates, although at the bottom of the scale, are only found at the present day in Madagascar and the adjacent regions of the globe. All the American Monkeys, moreover, belong to one group, much above the Lemurs, while the Old World Apes are higher still, and most nearly approach Man.

In the lower Eocene of New Mexico, we find a few representatives of the earliest known Primates, and among them are the genera *Lemuravus* and *Limnotherium*, each the type of a distinct family. These genera became very abundant in the middle Eocene of the West, and with them are found many others, all however, included in the two families, *Lemuravidæ* and *Limnotheridæ*. *Lemuravus* appears to have been most nearly allied to the Lemurs, and is the most generalized form of the Primates yet discovered. It had forty-four teeth, forming a continuous series above and below. The brain was nearly smooth, and of moderate size. The skeleton most resembles that of the Lemurs. A nearly allied genus, belonging to the same family, is *Hyopsodus*. *Limnotherium* (*Tomitherium*) also is nearly related to the Lemurs, but shows some affinities with the South American Marmosets. This genus had forty teeth. The brain was nearly smooth, and the cerebellum large, and placed mainly behind the cerebrum. The orbits are open behind, and the lachrymal foramen is outside the orbit. Other genera belonging to the *Limnotheridæ* are, *Notharctos*, *Hipposyus*, *Microsyops*, *Palæacodon*, *Thinolestes* and *Telmatolestes*. Besides these, *Antiacodon* (*Anaptomorphus*), *Bathrodon* and *Mesacodon* should probably be placed in the same group. In the Diplacodon Beds, or Upper Eocene, no remains of Primates have yet been detected, although they will doubtless be found there. All the Eocene Primates known from American strata are low generalized forms, with characters in the teeth, skeleton and feet that suggest relationships with the Carnivores, and even with the Ungulates. These resemblances have led palæontologists to refer some imperfect specimens to both these orders.

In the Miocene lake basins of the West, only a single species of the *Primates* has been identified with certainty. This was found in the Oreodon Beds of Nebraska, and belongs to the genus *Laopithecus*, apparently related both to the *Limnotheridæ* and to some existing South American Monkeys. In the Pliocene and Post-Pliocene of North America, no remains of Primates have yet been found.

In the Post-Pliocene deposits of the Brazilian caves, remains of Monkeys are numerous, and mainly belong to extinct species of *Callithrix*, *Cebus* and *Jacchus*, all living South American genera. Only one extinct genus, *Protopithecus*, which embraced animals of large size, has been found in this peculiar fauna.

It is a noteworthy fact, that no traces of any Anthropoid Apes, or indeed of any Old World Monkeys have yet been detected in America. Man, however, the highest of the Primates, has left his bones and his works from the Arctic Circle to Patagonia. Most of these specimens are clearly Post-Tertiary, although there is considerable evidence pointing to the existence of Man in our Pliocene. All the remains yet discovered belong to the well-marked genus *Homo*, and apparently to a single species, at present represented by the American Indian.

In this rapid review of Mammalian life in America, from its first known appearance in the Trias down to the present time, I have endeavored to state briefly the introduction and succession of the principal forms in each natural group. If time permitted, I might attempt the more difficult task of trying to indicate what relations these various groups may possibly bear to each other; what connection the ancient Mammals of this continent have with the corresponding forms of the Old World; and, most important of all, what real progress Mammalian life has here made since the beginning of the Eocene. As it is, I can only say in summing up, that the Marsupials are clearly the remnants of a very ancient fauna, which occupied this continent millions of years ago, and from which the other Mammals were doubtless all derived, although the direct evidence of the transformation is wanting.

Although the Marsupials are nearly related to the still lower Monotremes, now living in the Australian Region, we have as yet no hint of the path by which these two groups became separated from the inferior vertebrates. Neither have we to-day much light as to the genetic connection existing between Marsupials and the placental Mammalia, although it is possible that the different orders of the latter had their origin each from a separate group of the Marsupials.

The presence, however, of undoubted Marsupials in our lower and middle Eocene, some of them related to the genus *Didelphys*, although remotely, is important evidence as to the introduction of these animals into America. Against this, their supposed absence in our Miocene and Pliocene can have but limited weight, when taken in connection with the fact that they flourished in the Post-Tertiary, and are still abundant. The evidence we now have is quite as strongly in favor of a migration of Marsupials from America to the Old World, as the reverse, which has been supposed by some naturalists. Possibly, as Huxley has suggested, both countries were peopled with these low mammals from a continent now submerged.

The Edentate mammals have long been a puzzle to zoologists, and up to the present time no clew to their affinities with other groups seems to have been detected. A comparison of the peculiar Eocene Mammals which I have called the *Tillodontia*, with the least specialized Edentates, brings to light many curious resemblances in the skull, teeth, skeleton and feet. These suggest relationship, at least, and possibly we may yet find here the key to the Edentate genealogy. At present, the Tillodonts are all from the lower and middle Eocene, while *Moropus*, the oldest Edentate genus, is found in the middle Miocene, and one species in the lower Pliocene.

The Edentates have been usually regarded as an American type, but the few living forms in Africa, and the Tertiary species in Europe, the oldest known, have made the land of their nativity uncertain. I have already given you some reasons for believing that the Edentates had their first home in North America, and migrated thence to the southern portion of the continent. This movement could not have taken place in the Miocene period, as the Isthmus of Darien was then submerged; but near the close of the Tertiary, the elevation of this region left a much broader strip of land than now exists there, and over this, the Edentates and other mammals made their way, perhaps urged on by the increasing cold of the glacial winters. The evidence to-day is strongly in favor of such a southern migration. This, however, leaves the Old World Edentates, fossil and recent, unaccounted for; but I believe the solution of this problem is essentially the same, namely: a migration from North America. The Miocene representatives of this group, which I have recently obtained in Oregon, are older than any known in Europe, and, strangely enough, are more like the latter and the existing African types than like any of our living species. If, now, we bear in mind that an elevation of only 180 feet would, as has been said, close Behring's Straits, and give a road thirty miles wide from America to Asia, we can easily see how this migration might have taken place. That such a Tertiary bridge did exist, we have much independent testimony, and the known facts all point to extensive migrations of animals over it.

The *Cetacea* are connected with the marine Carnivores through the genus *Zeuglodon*, as Huxley has shown, and the points of resemblance are so marked that the affinity cannot be doubted. That the connection was a direct one, however, is hardly probable, since the diminutive brain, large number of simple teeth, and reduced limbs in the Whales, all indicate them to be an old type, which doubtless branched off from the more primitive stock leading to the Carnivores. Our American extinct Cetaceans, when carefully investigated, promise to throw much light upon the pedigree of these strange mammals. As most of the known forms were probably marine, their distribution is of little service in determining their origin.

That the Sirenians are allied to the Ungulates is now generally admitted by anatomists, and the separation of the existing species in distant localities suggests that they are the remnants of an extensive group, once widely distributed. The large number of teeth in some forms, the reduced limbs and other characters, point back to an ancestry near that of the earliest ungulates. The gradual loss of teeth in the specialized members of this group, and in the Cetaceans, is quite parallel with the same change in Edentates, as well as in Pterodactyls and Birds.

The Ungulates are so distinct from other groups that they must be one of the oldest natural divisions of mammals, and they probably originated from some herbivorous marsupial. Their large size, and great numbers during Tertiary and Post-tertiary time, render them most valuable in tracing migrations induced by climate, as well as in showing the changes of structure which such a contest for existence may produce.

In the review of the extinct Ungulates, I have endeavored to show that quite a number of genera usually supposed to belong originally to the Old World are in reality true American types. Among these were the Horse, Rhinoceros, and Tapir, all the existing odd-toed Ungulates, and besides these the Camel, Pig, and Deer. All these I believe, and many others, went to Asia from our North West Coast. It must, for the present, remain an open question whether we may not fairly claim the *Bovidæ*, and even the *Proboscidea*, since both occur in our strata at about the same horizon as on the other continent. On this point there is some confusion, at least in names. The Himalayan deposits called Upper Miocene, and so rich in Proboscideans, indicate in their entire fauna that they are more recent than our Niobrara River beds, which, for apparently good reasons, we regard as Lower Pliocene. The latter appear to be about the same horizon as the Pikermi deposits in Greece, also regarded as Miocene. Believing, however, that we have here a more complete Tertiary series, and a better standard for comparison of faunas, I have preferred to retain the names already applied to our divisions, until the strata of the two continents are more satisfactorily coördinated.

The extinct Rodents, Bats, and Insectivores of America, although offering many suggestive hints as to their relationship with other groups, and their various migrations, cannot now be fully discussed. There is little doubt, however, that the Rodents are a New World type, and, according to present evidence, they probably had their origin in North America. The resemblance in so many respects of this order to the Proboscideans is a striking fact, not yet explained by the imperfectly known genealogy of either group.

The Carnivores, too, I must pass by, except to call attention to a few special forms which accompanied the migrations of other groups. One of these is *Machairodus*, the saber-toothed Tiger, which flourished in our Miocene and Pliocene, and followed the huge Edentates to South America, and the Ungulates across Asia to Europe. With this genus went *Hyænodon*, and some typical Wolves and Cats, but the Bears came the other way with the Antelopes. That the Gazelle, Giraffe, Hippopotamus, Hyaena and other African types, once abundant in Asia, did not come, is doubtless because the Miocene bridge was submerged before they reached it.

The Edentates, in their southern migration, were probably accompanied by the Horse, Tapir and Rhinoceros, although no remains of the last have yet been found south of Mexico. The Mastodon, Elephant, Llama, Deer, Peccary, and other mammals, followed the same path. Why the Mastodon, Elephant, Rhinoceros, and especially the Horse, should have been selected with the huge Edentates for extinction, and the other Ungulates left, is at present a mystery, which their somewhat larger size hardly explains.

The relations of the American Primates, extinct and recent, to those of the other hemisphere, offer an inviting topic, but it is not in my present province to discuss them in their most suggestive phases. As we have here the oldest and most generalized members of the group, so far as now known, we may justly claim America for the birth-place of the order. That the development did not continue here until it culminated in Man, was due to causes which at present we can only surmise, although the genealogy of other surviving groups gives some data toward a solution. Why the old world Apes, when differentiated, did not come to the land of their earlier ancestry, is readily explained by the then intervening oceans, which likewise were a barrier to the return of the Horse and Rhinoceros.

Man, however, came; doubtless first across Behring's Straits; and at his advent became part of our fauna, as a mammal and primate. In these relations alone, it is my purpose here to treat him. The evidence, as it stands to-day, although not conclusive, seems to place the first appearance of Man in this country in the Pliocene, and the best proof of this has been found on the Pacific coast. During several visits to that region, many facts were brought to my knowledge which render this more than probable. Man at this time was a savage, and was doubtless forced by the great volcanic outbreaks to continue his migration. This was at first to the south, since mountain chains were barriers on the east. As the native Horses of America were now all extinct, and as the early man did not bring the old world animal with him, his migrations were slow. I believe, moreover, that his slow progress towards civilization was in no small degree due to this same cause, the absence of the Horse.

It is far from my intention to add to the many theories extant in regard to the early civilizations in this country, and their connections with the primitive inhabitants, or the later Indians, but two or three facts have recently come to my knowledge which I think worth mentioning in this connection. On the Columbia River, I have found evidence of the former existence of inhabitants much superior to the Indians at present there, and of which no tradition remains. Among many stone carvings which I saw there, were a number of heads which so strongly resemble those of Apes, that the likeness at once suggests itself. Whence came these sculptures, and by whom were they made? Another fact that has interested me very much is the strong resemblance between the skulls of the typical Mound-builders of the Mississippi Valley and those of the Pueblo Indians. I had long been familiar with the former, and when I recently saw the latter, it required the positive assurance of a friend who had himself collected them in New Mexico, to convince me that they were not from the mounds. A third fact, and I leave Man to the Archæologists, on whose province I am even now trenching. In a large collection of Mound-builders' pottery, over a thousand specimens, which I have recently examined with some care, I found many pieces of elaborate workmanship so nearly like the ancient water-jars from Peru, that no one could fairly doubt that some intercourse had taken place between the widely separated people that made them.

The oldest known remains of Man on this continent differ in no important characters from the bones of the typical Indian, although in some minor details they indicate a much more primitive race. These early remains, some of which are true fossils, resemble much more closely the corresponding parts of the highest Old World Apes, than do the latter our Tertiary Primates, or even the recent American Monkeys. Various living and fossil forms of old world Primates fill up essentially the latter gap. The lesser gap between the primitive Man of America and the Anthropoid Apes is partially closed by still lower forms of men, and doubtless also by higher Apes, now extinct. Analogy, and many facts as well, indicate that this gap was smaller in the past. It certainly is becoming wider now with every generation, for the lowest races of men will soon become extinct, like the Tasmanians, and the highest Apes cannot long survive. Hence the intermediate forms of the past, if any there were, become of still greater importance. For such missing links, we must look to the caves and later Tertiary of Africa, which I regard as now the most promising field for exploration in the Old World. America, even in the Tropics, can promise no such inducements to ambitious explorers. We have, however, an equally important field, if less attractive, in the Cretaceous Mammals, which must have left their remains somewhere on this continent. In these two directions, as I believe, lie the most important future discoveries in Palæontology.

As a cause for many changes of structure in mammals during the Tertiary and Post-Tertiary, I regard, as the most potent, *Natural Selection*, in the broad sense in which that term is now used by American evolutionists. Under this head, I include not merely a Malthusian struggle for life among the animals themselves, but the equally important contest with the elements, and all surrounding nature. By changes in the environment, migrations are enforced, slowly in some cases, rapidly in others, and with change of locality must come adaptation to new conditions, or extinction. The life-history of Tertiary mammals illustrates this principle at every stage, and no other explanation meets the facts.

The real progress of mammalian life in America, from the beginning of the Tertiary to the present, is well illustrated by the Brain-growth, in which we have the key to many other changes. The earliest known Tertiary mammals all had very small brains, and in some forms this organ was proportionally less than in certain Reptiles. There was a gradual increase in the size of the brain during this period, and it is interesting to find that this growth was mainly confined to the cerebral hemispheres, or higher portion of the brain. In most groups of mammals, the brain has gradually become more convoluted, and thus increased in quality, as well as quantity. In some, also, the cerebellum, and olfactory lobes, the lower parts of the brain, have even diminished in size. In the long struggle for existence during Tertiary time, the big brains won, then as now; and the increasing power thus gained rendered useless many structures inherited from primitive ancestors, but no longer adapted to new conditions.

Another of the interesting changes in mammals during Tertiary time was in the teeth, which were gradually modified with other parts of the structure. The primitive form of tooth was clearly a cone, and all others are derived from this. All classes of vertebrates below mammals, namely, Fishes, Amphibians, Reptiles, and Birds, have conical teeth, if any, or some simple modification of this form. The Edentates and Cetaceans with teeth retain this type, except the Zeuglodonts, which approach the dentition of aquatic Carnivores. In the higher mammals, the incisors and canines retain the conical shape, and the premolars have only in part been transformed. The latter gradually change to the more complicated molar pattern, and hence are not reduced molars, but transition forms from the cone to more complex types. Most of the early Tertiary mammals had forty-four teeth, and in the oldest forms the premolars were all unlike the molars; while the crowns were short, covered with enamel, and without cement. Each stage of progress in the differentiation of the animal was, as a rule, marked by a change in the teeth; one of the most common being the transfer, in form at least, of a premolar to the molar series, and a gradual lengthening of the crown. Hence, it is often easy to decide from a fragment of a jaw, to what horizon of the Tertiary it belongs. The fossil Horses of this period, for example, gained a grinding tooth, for each toe they lost, one in each epoch. In the single-toed existing horses, all the premolars are like the molars, and the process is at an end. Other dental transformations are of equal interest, but this illustration must suffice.

The changes in the limbs and feet of mammals during the same period were quite as marked. The foot of the primitive mammal was doubtless plantigrade, and certainly five-toed.

Many of the early Tertiary forms show this feature, which is still seen in some existing forms. This generalized foot became modified by a gradual loss of the outer toes, and increase in size of the central ones; the reduction proceeding according to systematic methods, differing in each group. Corresponding changes took place in the limb bones. One result was a great increase in speed, as the power was applied so as to act only in the plane of motion. The best effect of this specialization is seen to-day in the Horse and Antelope, each representing a distinct group of Ungulates, with five-toed ancestors.

If the history of American Mammals as I have briefly sketched it, seems as a whole incomplete, and unsatisfactory, we must remember that the genealogical tree of this class has its trunk and larger limbs concealed beneath the *débris* of Mesozoic time, while its roots doubtless strike so deeply into the Paleozoic that for the present they are lost. A decade or two hence, we shall probably know something of the mammalian fauna of the Cretaceous, and the earlier lineage of our existing mammals can then be traced with more certainty.

The results I have presented to you are mainly derived from personal observation; and since a large part of the higher vertebrate remains found in this country have passed through my hands, I am willing to assume full responsibility for my presentation of the subject.

For our present knowledge of the extinct Mammals, Birds and Reptiles of North America, science is especially indebted to Leidy, whose careful, conscientious work has laid a secure foundation for our vertebrate palæontology. The energy of Cope has brought to notice many strange forms, and greatly enlarged our literature. Agassiz, Owen, Wyman, Baird, Hitchcock, Deane, Emmons, Lea, Allen, Gibbes, Jefferson, DeKay, and Harlan, deserve honorable mention in the history of this branch of science. The South American extinct vertebrates have been described by Lund, Owen, Burmeister, Gervais, Huxley, Flower, Desmarest, Aymard, Pictet, and Nodot. Darwin and Wallace have likewise contributed valuable information on this subject, as they have on nearly all forms of life.

In this long history of ancient life I have said nothing of what Life itself really is. And for the best of reasons, because I know nothing. Here at present our ignorance is dense, and yet we need not despair. Light, Heat, Electricity, and Magnetism, Chemical Affinity and Motion, are now considered different forms of the same force; and the opinion is rapidly gaining ground that Life, or vital force, is only another phase of the same power. Possibly the great mystery of Life may thus be solved, but whether it be or not, a true faith in Science knows no limit to its search for Truth.

ART. XLIII.—*Note on the Helderberg Formation of Bernardston, Massachusetts, and Vernon, Vermont;* by JAMES D. DANA.

IN examinations of the Bernardston Helderberg formation which were the basis of my former paper "On the Rocks of the Helderberg era in the Valley of the Connecticut"[*] my main purpose was lithological—that is, to ascertain and point out the kinds of crystalline rocks that were comprised within terranes of Helderberg (later Upper Silurian) age. The conformable position of the Bernardston limestone beneath strata of quartzyte and slate, first made known by Professor Edward Hitchcock,[†] I found to be, as I thought, a fact; and from there I traced the quartzyte at intervals, along with the slate—a peculiar mica slate easily distinguished by the minute garnets which gave its layers a pimpled surface, and the small crystals of mica set transversely to the lamination—over the country, to South Vernon in Vermont; and announced in my paper that the Helderberg formation included, besides the quartzyte and mica slate, beds of compact green hornblende rock, a rock of the composition of syenyte, staurolitic mica slate, coarse mica schist, whitish and grayish quartzose gneiss, and all stages of passage between quartzyte and gneiss.

Recently, Professor C. H. Hitchcock, in the Second Volume of his Report on the Geology of New Hampshire,[‡] and more briefly in a note in this Journal,[§] has suggested that the order of stratification at the limestone locality is not the true order; that the rocks may be "in an inverted position:" that the limestone stratum may have *overlaid* both the other formations, that is, the quartzyte and mica slate;[‖] that "the limestone occupies a small valley in the quartzyte."[¶] Having, through this supposition, made the limestone the newest of the formations, he concludes, further, that the mica slate, now lying over it, is not necessarily Helderberg; that the hornblende rocks and gneiss of Vernon are not necessarily of the Helderberg series,[**] and neither the staurolitic slate; that a long period intervened between the deposition of the hornblendic stratum and quartzyte.

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[*] This Journal, III, vi, 339.

[†] Report on the Geology, etc. of Massachusetts, by E. Hitchcock, 8vo, 1833, p. 295; Report of Amer. Assoc. for 1851, p. 299; Report Geol. of Vermont, 2 vols. 4to, 1861, p. 447. This last notice was prepared in conjunction with Mr. C. H. Hitchcock. It gives a section representing the limestone dipping beneath quartzyte and slate.

[‡] Page 428 and beyond, 1877.

[§] Vol. xiii, page 313, April, 1877.

[‖] Ibid.

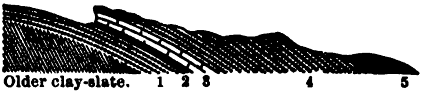
[¶] Report New Hampshire, vol. ii, p. 455.

[**] It should be added here that the volume of the N. Hampshire Geological Report referred to conveys on an earlier page (p. 18), a different opinion as to the limits of the Helderberg, where it is stated that the Connecticut Valley Helderberg series consists of several thousand feet in thickness of quartzytes, limestones, slates, conglomerates, sandstones, flags, and probably hornblende schists.

While thus dissenting from my conclusions, Professor Hitchcock adopts my suggestion that the garnetiferous mica slate which overlies the quartzyte and limestone at the Bernardston limestone locality is identical with the Coös slate of the Connecticut Valley in all its characters and age, and hence that *if* the former should turn out after all to be Helderberg, the Coös formation (which extends up the valley to Canada, according to Professor Hitchcock) is also Helderberg or later Upper Silurian.

These differences of opinion, and the wide bearing of the facts on New England geology have led me to revisit the place and examine it anew. In my former paper I closed by stating my intention, another season, to study the stratigraphical details of the region, and trace out the limits or range of the formations southward along the Connecticut Valley. But other geological work in Western and Southern New England, and on the islands off its southern coast, have since occupied such leisure time as I could command. In my recent visit to Bernardston I was accompanied by Professor B. K. Emerson, of Amherst College; and it is a great satisfaction to know that he will give the whole subject a careful and thorough study, and connect it with a general geological survey of Central and Western Massachusetts—work for which he is eminently fitted.

To facilitate explanations I repeat the section of the strata at the Bernardston locality before published, with one correction. No. 3, the blocked area, represents the stratum of Crinoidal limestone; Nos. 1 and 4, dotted areas, an underlying and an overlying stratum of quartzyte; and Nos. 2 and 5, finely lined areas, an underlying and an overlying stratum of garnetiferous mica slate. The succession and position are the same as in the section by Professor Hitchcock in the Vermont Geological Report, excepting the omission here of a layer of slate immediately *over* the limestone.



The conclusions which the facts appear to me to sustain, in opposition to those set forth by Professor C. H. Hitchcock in the New Hampshire Report of 1877, but mostly in agreement with Mr. C. H. Hitchcock of the Vermont Report* (p. 598) of 1861—are the following:

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* The Vermont Report makes no mention, in the chapter on the Bernardston limestone (p. 447), of the hornblende rocks, gneiss, etc., of the adjoining region on the east. But on page 598, in an account of "Section I," extending across the

1. That the quartzyte is Helderberg as much as the limestone.
2. That the garnetiferous mica slate is equally Helderberg.
3. That the limestone is a local deposit between the other members of the Helderberg formation.
4. That hornblende rocks, staurolitic slate, mica schist and gneiss of the adjoining region on the east and northeast are of one and the same geological formation.

1. *The Quartzyte is of the Helderberg formation.* The overlying quartzyte (No. 4) besides occurring in large outcrops over the hill-side, *constitutes the upper two to four feet* of the vertical section exposed in a portion of the limestone quarry. This alone proves its conformable position and close relation to the limestone. But further, while this overlying quartzyte is in part very compact and solid, some portions are very cellular from the removal of calcareous matter and pyrite, and also from the removal of fossils. The first of the fossils was found by Professor Emerson, while we were together, and was a cast of a *Pentamerus;* and both of us afterward obtained other specimens. The casts were too imperfect for a decision as to the species; but they appear to show that it was nearly equal in height and breadth, and without costæ, which are characteristics of the *P. pseudo-galeatus*, a Lower Helderberg species. Besides these brachiopods, there were in the same layers of the quartzyte numerous fragments of *crinoidal stems*, mostly of small species. Some of the laminæ of this quartzyte have between them mica in scales, so as to look in a surface view like mica schist.

The fact that there is conformability between the limestone and quartzyte is hence beyond question. And it is equally certain that, overturned or not, the quartzyte belongs to the same

south extremity of the State near the Massachusetts boundary, Mr. C. H. Hitchcock describes the hornblende rocks of Vernon and Bernardston as associated with gneiss and mica schists; states that the mica schist west of South Vernon contains chiastolite [staurolite?]; speaks of the gneiss as graduating insensibly into the quartz rock, as in some places difficult to be distinguished from granite, as also "invariably resting upon the quartz rock" and hence "newer" than it; as, therefore, probably of the Upper Helderberg age, like the Bernardston limestone (Hall's first determination), which rests on the same quartz rock; thus making the whole series Upper Helderberg. The unconformability of the quartz rock series on the clay slate is also recognized.

If these were still his views, excepting the change of Upper Helderberg to Lower Helderberg, we should be in close agreement. In my arguments above, I am in fact sustaining Mr. C. H. Hitchcock of 1861, against Professor C. H. Hitchcock of 1877) whose later conclusions have been influenced by his faith in the lithological test of geological age, and his unbelief in the existence of gneiss-like metamorphic rocks of later date than Cambrian.

The suspicion that C. H. Hitchcock may not have been the author of the notes on Section I is apparently set aside by the heading of the Chapter, "Notes on the Sections, by C. H. Hitchcock," and the absence of any statement that the notes on Section I were prepared by any other person.

era with the crinoidal limestone; for the former really graduates into the latter as its calcareous matter and fossils show.

2. *The garnetiferous mica slate is of the Helderberg formation.*—This is demonstrated by the existence of a stratum of garnetiferous mica slate (No. 2, in the section, p. 380,) *beneath* the limestone as well as one (No. 5) above. This inferior mica slate wants the little disseminated crystals of mica common in the other; but it is pimpled with garnets like that. The line of outcrops extends for several rods, and runs along within a few yards of the limestone, at the nearest point hardly a yard of earth intervening; and the strike and dip throughout correspond with that of the limestone adjoining. Having garnetiferous mica slate below the limestone as well as above, and the three strata conformable in dip, there can be no reasonable doubt that all are of one formation. The limestone stratum is so placed with reference to those above and below that it could not have been originally at the top, and the newest of the series. Whatever faulting or inversion be supposed, it must have had originally, as it has now, an overlying and an underlying mica slate.

3. *The limestone a local deposit in the Helderberg formation.*—The fact that the limestone has not been observed elsewhere in the region is no evidence of independent and later formation. It is plainly an isolated bed, of limited lateral extent, *like those that are so common in the widely spread "Calciferous mica schist" of the Connecticut Valley.* The fact that it is a wedge-shaped mass thus isolated is evident; for just north of the main quarry it soon thins out, (together with the thin underlying stratum of mica slate) through the approach and junction of the overlying and underlying quartzyte. Fossils, if found in any of the many isolated calcareous deposits in the "Calciferous mica schist," would be regarded as showing the age of the schist; and so it should be here.

Professor Hitchcock says that if the Coös slate is Helderberg, the Calciferous mica schist is unquestionably so too. Admitting this to be true, the parallelism between the Bernardston limestone and the isolated calcareous deposits in the schist becomes complete.*

4. *The hornblende rocks, staurolitic slate, mica schist and associated gneiss are of the Helderberg formation.*—As limestone has been found in the region only at the one locality in Bernardston, the evidence of equivalence has to be derived from the distribution of its associated rocks. This evidence, east and northeast of the Bernardston village-plain, is as follows:

(1.) The same garnetiferous mica slate with disseminated brown mica crystals set transversely that occurs associated

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*** My knowledge of the rock formations of Western Vermont is not sufficient to warrant an independent opinion with regard to the "Calciferous mica schist."**

with quartzyte at the Bernardston locality on the west side of the Bernardston plain occurs associated with quartzyte at different points between Bernardston and Vernon. It sometimes dips beneath quartzyte and sometimes overlies it.

(2.) Outcrops of the quartzyte and the peculiar Bernardston mica slate together appear east and northeast of Bernardston within one to one and a half miles of the Crinoidal limestone locality (the intervening flat valley being under drift and alluvium), and at intervals beyond, to Vernon, with the same aspect and conformable superposition as at the limestone locality.

(3.) In the same region, hornblende rocks, staurolitic slate, gneiss and mica schist occur in alternating beds with the Bernardston mica slate and quartzyte.

A mile and a half east of Bernardston,* the Bernardston mica slate occurs in alternating beds with the hornblende rock, —a gray-green compact rock, not schistose—with so obvious junctions that the alternation cannot be questioned. The hornblende rock (1) dips beneath (2) mica slate; this beneath (3) hornblende rock; and the last beneath (4) mica slate again. Whether there is a fault between 2 and 3 is not certain; but it is unquestionable that 1 and 2, and 3 and 4 are strictly conformable. Part of the hornblende rock is speckled white with quartzyte and feldspar and is like a quartzytic syenite in constitution, though unlike true syenyte in aspect.

Again: a mile to the north of the last-mentioned locality and less than a mile and a half northeast of the Bernardston limestone locality, the same peculiar mica slate may be seen, dipping at a small angle beneath a stratum of quartzyte, the conformability, as in other cases in the region, unquestionable. Now this quartzyte stratum, while in part quartzyte, is partly a tough micaceous rock consisting chiefly of aggregated scales of brown mica, but with some hornblende and quartz.

Again: the Bernardston slate of the locality just mentioned extends eastward and is the same stratum, as well as the same kind of slate, with that of Purple's quarry, described in my former paper; which slate contains occasional crystals of *staurolite*. Hence the Bernardston slate which alternates with quartzyte is in some places a *staurolitic slate*. Another place, farther east, is mentioned in my former paper where the slate is abundantly staurolitic.

Again: in Vernon, four to five miles northwest of South Vernon, where the quartzyte is largely exposed to view, one of the quartzyte knolls consists partly of mica rock like that above described, made up mainly of aggregated scales of brown mica but containing distributed through it some quartz and hornblende. In other outcrops in the field adjoining, the rock is mostly true quartzyte, but partly a green compact hornblende rock, with insensible gradations between it and the quartzyte.

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* For the position of this locality see my former paper.

Again: at South Vernon, over the slopes nearly west of the hotel, there occur—first quartzyte, but with it, and graduating into it, the compact green hornblende rock; then, high up the slope, a coarse garnetiferous mica schist consisting mainly of brown mica, which is nothing but a coarse form of the Bernardston slate; and in this mica schist there are hornblendic layers; and some beds which consist of a quartzytic syenyte, though with the hornblende grains in slender crystals.

Again: between Vernon Center and South Vernon, there are outcrops showing the transition between the quartzyte and a quartzytic gneiss. The gneiss has the aspect of any ordinary light-colored thick-bedded gneiss. But it is all quartzytic, and in part very largely so.

Besides this light-colored quartzytic gneiss, there is also, north of South Vernon, quartzytic syenite, a whitish rock containing small grains of greenish hornblende, rather sparsely disseminated, without mica, and making a handsome rock which might at first be taken for a white granite.

5. *Conclusion.*—Thus, the region affords examples (1) of the *interstratification* of the quartzyte and Bernardston mica slate, with a green massive hornblende rock; with a syenytic rock; with gneiss; and with coarse mica schist; (2) of *transitions* of the Bernardston mica slate into staurolitic slate and mica schist; and (3) of *transitions* of the quartzyte into (*a*) micaceous quartzyte; (*b*) a tough quartzytic mica rock, more or less hornblendic; (*c*) quartzytic gneiss often granitoid: (4) green hornblende rock; and (5) syenyte, besides various intermediate forms. For some other examples of these transitions I refer to my former paper.

The demonstration is certainly complete that whatever the age of the quartzyte and the associated Bernardston mica slate, the same is the age of the rocks above mentioned; and that the fossils of the Bernardston locality decide the age approximately for the series; and finally, that all are of the Helderberg formation or later Upper Silurian, if that is true of the Crinoidal limestone.

6. *Lithological characteristics.*—In using the lithological test of geological age it must hence be noted that the following may be rocks of metamorphic Upper Silurian formations: mica slate and schist; staurolitic mica slate; hornblendic rocks, varying from a kind consisting mainly of green hornblende to a quartzytic syenyte, and hornblendic quartzyte; quartzytic gneiss; true gneiss; micaceous quartzyte; quartzyte.

The minerals included among the abundant metamorphic species are: brown and white mica, the former much the most common; staurolite; green and black hornblende; orthoclase; garnet; along with pyrite, magnetite, and granular limestone.

The mica slate and schist and the staurolitic mica slate are not distinguishable from kinds that are of earlier age.

The hornblende rocks are peculiar. Those which are made mainly of hornblende have a dark green color, and are massive, often indistinct in bedding instead of schistose and much jointed. The larger part consist of minute interlaced fibers; with sometimes whitish spots giving the rock a porphyritic aspect, which spots consist of quartzyte combined usually with grains of orthclase. Thin slices in polarized light under the microscope are beautiful objects. A cleavable granular variety occurs but is less common. Coarser kinds have the hornblende in oblong pointed crystals imbedded in fine grained quartzyte or quartzyte and orthoclase.

The whitish quartzytic syenite mentioned on the preceding page is peculiar in having a very fine grain; the hornblende dark green in color, and generally in oblong grains; and the whiter portions of the rock of an opaque white color and made up mostly of grains of orthoclase. In a thin slice, these whiter portions lie between others that are pellucid and consist of quartz grains with few of feldspar.

The gneiss also is peculiar. It generally consists very largely of grains of quartz, even where looking to the eye like a true gneiss. The mica is almost solely the brown kind and is like that of the mica slate, though often seeming to have as little elasticity as chlorite; and the regular disposition of the spots of mica, give to the most quartzytic varieties a strikingly gneiss-like look. Professor Hitchcock refers the rock to the Bethlehem gneiss. But "the most characteristic of the rocks comprising this formation," he says, speaking of the Bethlehem gneiss, "is a reddish granitic gneiss, the flesh-colored orthoclase predominating, with chloritic or some hydro-micaceous mineral in place of ordinary mica, and quartz in variable proportions" (Report, p. 105); and to such a rock it has little resemblance. Yet, it is to be admitted that there is nothing in the amount of orthoclase in characteristic "Bethlehem gneiss" which renders connection with a Helderberg formation improbable.

The quartzyte in some places—as two miles west of South Vernon,—contains much pearly mica (hydrous mica?); a weathered surface of such a specimen shows that the rock consists mainly of quartz. In other places the quartzyte is marked with dark-gray and blackish lines where the mica is not distinguishable without a glass. All of it indicates by its fineness of texture, and sometimes even flinty aspect, that the quartz sand of which it was made was very finely comminuted, and not coarse like that from which the Green Mountain quartzyte was made; and hence that the region, when the deposition took place, was not the border of the open sea.

7. *Origin of the Rocks.*—To understand the rocks of this Helderberg region, it must be borne in mind: that quartzyte beds in their original state, that is, beds of quartz sand, may have been formed at different times in the course of the era, owing to changes of level or of currents; that the sand beds—like those of any other era and of the present time—would, in many places, have had more or less earthy material (ground-up crystalline rock) with the quartz sand, so that metamorphism could not make pure quartzyte out of it, but might make a micaceous or gneissoid quartzyte, or a quartzytic gneiss, according to the nature of the earthy material present; that while sand-beds were formed where the currents were rapid enough for the purpose, mud-beds would have formed where the waters were more quiet, as now on all coasts (for sand-beds never exist along shores without cotemporaneous mud-beds within a distance that is not great); and that from these mud-beds, or beds of finely triturated rocks, the mica slate, mica schist, or mica rock, and the hornblende rocks would have been produced. The existence of some potash and alumina in the triturated rock or mud (both ingredients of orthoclase) would have favored the formation of brown mica (biotite) by metamorphism, while the presence of lime or rather a calcium compound, that of hornblende: magnesia and iron being in about the same proportion in the hornblende as in the mica. Analyses of average biotite and dark green hornblende afford:

	Biotite.	Hornblende.
Silica	40	45
Alumina	18	10–12
Iron protoxide Iron sesquioxide	10	10
Magnesia	22	20
Lime	--	14
Potash	10	--

The magnesia would have come from the trituration of such older rocks as are made partly or wholly of minerals containing it; of which minerals, hornblende and biotite are the most common.

Admitting the Coös formation of Professor Hitchcock, and the Calciferous mica schist adjoining it, to be of the same formation with the mica slate, quartzyte, and hornblende rocks of the Bernardston and Vernon region, which Professor H. states to be a fact, this Helderberg formation stretches northward beyond the boundary of New England, with a breadth along the Connecticut Valley of fifteen to thirty miles or more:

breadth enough where narrowest—as at Bernardston—for a clear sea good for growing corals and crinoids. Whether Professor Hitchcock's Lisbon and Lyman groups, which he refers to the Huronian, are not to be included, remains to be ascertained, as indicated on page 317 of this volume. Adding them, it would follow that the Connecticut bay or channel of the Helderberg era covered a large part of Northern New Hampshire, and was connected with a great area in Maine marked off by the occurrence of Helderberg and Devonian fossils.

ART. XLIV.—*History of Cavern Exploration in Devonshire, England;* by W. PENGELLY, F.R.S., F.G.S., President of the Geological Section of the British Association at Plymouth.

[Continued from page 308.]

Brixham Cavern.—Early in 1858 an unsuspected cavern was broken into by quarrymen at the northwestern angle of Windmill Hill at Brixham, at a point seventy-five feet above the surface of the street, almost vertically below, and 100 feet above mean tide. On being found to contain bones, a lease in it was secured for the Geological Society of London, who appointed a committee of their members to undertake its exploration; funds were voted by the Royal Society, and supplemented by private subscriptions; the conduct of the investigation was intrusted to Mr. Prestwich and myself; and the work, under my superintendance, as the only resident member of the committee, was begun in July, 1858, and completed at midsummer, 1859.

The cavern, comprised within a space of 135 feet from north to south, and 100 from east to west, consisted of a series of tunnel galleries from six to eight feet in greatest width, and ten to fourteen feet in height, with two small chambers and five external entrances.

The deposits, in descending order, were:—

1st, or uppermost; a floor of stalagmite, from a few inches to a foot thick, and continuous over very considerable areas, but not throughout the entire cavern.

2d. A mass of small angular fragments of limestone, cemented into a firm concrete with carbonate of lime, commenced at the principal entrance, which it completely filled, and whence it extended thirty-four feet only. It was termed the *first bed.*

3d. A layer of blackish matter, about twelve feet long, and nowhere more than a foot thick, occurred immediately beneath the first bed, and was designated the *second bed.*

4th. A red, tenacious, clayey loam, containing a large number of angular and subangular fragments of limestone, varying from very small bits to blocks a ton in weight, made up the *third bed.* Pebbles of trap, quartz and limestone were somewhat prevalent, whilst nodules of brown hematite and blocks of stalagmite were occasionally met with in it. The usual depth of the bed was from two to four feet, but this was exceeded by four or five feet in two localities.

5th. The third bed lay immediately on an accumulation of pebbles of quartz, greenstone, grit and limestone, mixed with small fragments of shale. The depth of this, known as the *fourth* or *gravel bed*, was undetermined; for, excepting a few feet only, the limestone bottom was nowhere reached. There is abundant evidence that this bed, as well as a stalagmitic floor which had covered it, had been partially broken up and dislodged before the introduction of the third bed.

Organic remains were found in the stalagmitic floor and in each of the beds beneath it, with the exception of the second only; but as ninety-five per cent of the whole series occurred in the third, this was not unfrequently termed the *bone bed.*

The mammals represented in the stalagmite were bear, reindeer, *Rhinoceros tichorhinus*, mammoth, and cave lion.

The first bed yielded bear and fox only.

In the third bed were found relics of mammoth, *Rhinoceros tichorhinus*, horse, *Bos primigenius*, *B. longifrons*, red deer, reindeer, roebuck, cave lion, cave hyæna, cave bear, grizzly bear, brown bear, fox, hare, rabbit, *Lagomys spelæus*, water-vole, shrew, polecat and weasel.

The only remains met with in the fourth bed were those of bear, horse, ox and mammoth.

The human industrial remains exhumed in the cavern were flint implements and a hammer-stone, and occurred in the third and fourth beds only. The pieces of flint met with were thirty-six in number. Of these, fifteen are held to show evidence of having been artificially worked, in nine the workmanship is rude or doubtful, four have been mislaid, and the remainder are believed not to have been worked at all (see Phil. Trans., vol. clxiii, 1873, pp. 561, 562). Of the undoubted tools, eleven were found in the third and four in the fourth bed. Two of those yielded by the third bed, found forty feet apart, in two distinct but adjacent galleries, and one a month before the other, proved to be parts of one and the same *nodule*-tool; and I have little or no doubt that it had been washed out of the fourth bed and re-deposited in the third.

The hammer-stone was a quartzite pebble, found in the upper portion of the fourth bed, and bore distinct marks of the use to which it had been applied.

Speaking of the discovery of the tools just mentioned, Mr. Prestwich said in 1859:—"It was not until I had myself witnessed the conditions under which flint implements had been found at Brixham, that I became fully impressed with the validity of the doubts thrown upon the previously prevailing opinions with respect to such remains in caves" (Phil. Trans., 1860, p. 280); and according to Sir C. Lyell, writing in 1863: —"A sudden change of opinion was brought about in England respecting the probable coëxistence, at a former period, of man and many extinct mammalia, in consequence of the results obtained from the careful exploration of a cave at Brixham. . . . The new views very generally adopted by English geologists had no small influence on the subsequent progress of opinion in France" ("Antiquity of Man," pp. 96, 97).

Bench Cavern.—Early in 1861 information was brought me that an ossiferous cave had just been discovered at Brixham, and, on visiting the spot, I found that, of the limestone quarries worked from time to time in the northern slope of Furzeham Hill, one known as Bench Quarry, about half a mile due north of Windmill Hill Cavern, and almost overhanging Torbay, had been abandoned in 1839, and that work had been recently resumed in it. It appeared that in 1839 the workmen had laid bare the greater part of a vertical dike, composed of red clayey loam, and angular pieces of limestone, forming a coherent wall-like mass, twenty-seven feet high, twelve feet long, two feet in greatest thickness, and at its base 123 feet above sea-level. In the face of it lay several fine relics of the ordinary cave mammals, including an entire left lower jaw of *Hyæna spelæa* replete with teeth, but which had nevertheless failed to arrest the attention of the incurious workmen who exposed it, or of any one else.

Soon after the resumption of the work in 1861, the remnant of the outer wall of the fissure was removed, and caused the fall of an incoherent part of the dike, which it had previously supported. Amongst the *débris* the workmen collected some hundreds of specimens of skulls, jaws, teeth, vertebræ, portions of antlers, and bones, but no indications of man. Mr. Wolston, the proprietor, sent some of the choicest specimens to the British Museum, and submitted the remainder to Mr. Ayshford Sanford, F.G.S., from whom I learn that the principal portion of them are relics of the cave hyæna, from the unborn whelp to very aged animals. With them; however, were remains of bear, reindeer, ox, hare, *Arvicola ratticeps*, *A. agrestis*, wolf, fox, and part of a single maxillary with teeth not distinguishable from those of *Canis isatis*. To this list I may add rhinoceros, of which Mr. Wolston showed me at least one bone.

From the foregoing undesirably, but unavoidably, brief descriptions, it will be seen that the Devonshire caverns, to which attention has been now directed, belong to two classes, —those of Oreston, the Ash-Hole, and Bench being *Fissure Caves;* whilst those of Yealm Bridge, Windmill Hill at Brixham, Kent's Hole, and Ansty's Cove are *Tunnel Caves.*

Windmill Hill and Kent's Hole Caverns have alone been satisfactorily explored; and besides them none have yielded evidence of the contemporaneity of man with the extinct cave mammals.

Oreston is distinguished as the only known British cavern which has yielded remains of *Rhinoceros leptorhinus* (Quart. Journ. Geol. Soc., xxxvi, p. 456).

Yealm Bridge Cavern, if we may accept Mr. Bellamy's identification in 1835, was the first in this country in which relics of glutton were found (South Devon Monthly Museum, vi, pp. 218–223; see also "Nat. Hist. S. Devon," 1839, p. 89). The same species was found in the caves of Somerset and Glamorgan in 1865 (Pleist. Mam., Pal. Soc., pp. xxi, xxii), in Kent's Hole in 1869 (Rep. Brit. Assoc., 1869, p. 207), and near Plas Heaton, in North Wales, in 1870 (Quart. Jour. Geol. Soc.), xxvii, p. 407).

Kent's Hole is the only known British cave which has afforded remains of beaver (Rep. Brit. Assoc., 1869, p. 208), and up to the present year the only one in which the remains of *Machœrodus latidens* had been met with. Indeed Mr. MacEnery's statement, that he found in 1826 five canines and one incisor of this species in the famous Torquay Cavern was held by many paleontologists to be so very remarkable as, at least, to approach the incredible, until the Committee now engaged in the exploration exhumed, in 1872, an incisor of the same species, and thereby confirmed the announcement made by their distinguished predecessor nearly half a century before (Rep. Brit. Assoc., 1872, p. 46). In April last (1877) the Rev. J. M. Mello was able to inform the Geological Society of London that Derbyshire had shared with Devon the honor of having been a home of *Machœrodus latidens,* he having found its canine tooth in Robin Hood Cave in that county, and that there, as in Kent's Hole, it was commingled with remains of the cave hyæna and his contemporaries (Abs. Proc. Geol. Soc., No. 334, pp. 3, 4).

The Ash-Hole, as we have already seen, afforded the first good evidence of a British reindeer.

In looking at the published reports on the two famous Torbay caverns it will be found that they have certain points of resemblance as well as some of dissimilarity:

1st. The lowest known bed in each is composed of materials which, while they differ in the two cases, agree in being such as may have been furnished by the districts adjacent to the cavern-hills respectively, but not by the hills themselves, and must have been deposited prior to the existing local geographical conditions. In each, this bed contained flint implements and relics of bear, but in neither of them those of hyæna. In short, the *fourth bed* of Windmill Hill Cavern, Brixham, and the *breccia* of Kent's Hole, Torquay, are coëval, and belong to what I have called the *Ursine* period of the latter.

2d. The beds just mentioned were in each cavern sealed with a sheet of stalagmite, which was partially broken up, and considerable portions of the subjacent beds were dislodged before the introduction of the beds next deposited.

3d. The great bone bed, both at Brixham and Torquay, consisted of red clayey loam, with a large percentage of angular fragments of limestone; and contained *flake* implements of flint and chert, inosculating with remains of mammoth, the tichorhine rhinoceros, and hyæna. In fine, the *cave-earth* of Kent's Hole and the *third bed* of Brixham Cavern correspond in their materials, in their osseous contents, and in their flint tools. They both belong to what I have named the *Hyænine* period of the Torquay Cave.

But, as already stated, there are points in which the two caverns differ:

1st. While Kent's Hole was the home of man, as well as of the contemporary hyæna during the absences of the human occupant, there is no reason to suppose that either man or any of the lower animals ever did more than make occasional visits to Brixham cave. The latter contained no flint chips, no bone tools, no utilized *Pecten*-shells, no bits of charcoal, and no coprolites of hyæna, all of which occurred in the cave-earth of Kent's Hole.

2d. In the Torquay Cave, relics of hyæna were much more abundant in the cave-earth than those of any other species. Taking the teeth alone, of which vast numbers were found, those of the hyæna amounted to about 30 per cent of the entire series, notwithstanding the fact that, compared with most of the cave-mammals, his jaws, when furnished completely, possess but few teeth. At Brixham, on the other hand, his relics of all kinds amounted to no more than 8·5 per cent of all the osseous remains, while those of the bear rose to 53 per cent.

3d. The entrances of Brixham Cavern were completely filled up and its history suspended not later than the end of the Paleolithic era. Nothing occurred within it from the days when Devonshire was occupied by the cave and grizzly bears, reindeer, rhinoceros, cave lion, mammoth, and man, whose best tools were unpolished flints, until the quarrymen broke into it early in A. D. 1858. Kent's Cavern, on the contrary, seems to have never been closed, never unvisited by man, from the earliest Paleolithic times to our own, with the possible exception of the Neolithic era, of which it cannot be said to have yielded any certain evidence.

Though my "History of Cavern Exploration in Devonshire" is now completed, so far as the time at my disposal will allow, and so far as the materials are at present ripe for the historian, I venture to ask your further indulgence for a few brief moments while passing from the region of fact to that of inference.

That the Kent's Hole men of the Hyænine period—to say nothing at present of their predecessors of the Breccia—belonged to the Pleistocene times of the biologist, is seen in the fact that they were contemporary with mammals peculiar to and characteristic of those times. This contemporaneity proves them to have belonged to the *Paleolithic* era of Britain and Western Europe generally, as defined by the archeologist; and this is fully confirmed by their unpolished tools of flint and chert. That they were prior to the deposition of even the oldest part of the peat bogs of Denmark, with their successive layers of beech, pedunculated oak, sessile oak, and Scotch fir, we learn from the facts that even the lowest zone of the bogs has yielded no bones of mammals but those of recent species, and no tools but those of *Neolithic* type; whilst even the granular stalagmite, the uppermost of the Hyænine beds in Kent's Hole, has afforded relics of mammoth, *Rhinoceros tichorhinus*, cave bear, and cave hyæna.

That the men of the Cave Breccia, or Ursine period, to whom we now turn, were of still higher antiquity, is obvious from the geological position of their industrial remains. That the two races of Troglodytes were separated by a wide interval of time we learn from the sheet of crystalline stalagmite, sometimes twelve feet thick, laid down after the deposition of the breccia had ceased, and before the introduction of the cave-earth had begun, as well as from the entire change in the materials composing the two deposits. But, perhaps, the fact which most emphatically indicates the chronological value of this interval is the difference in the faunas. In the cave-earth, as already stated, the remains of the hyæna greatly exceed in number those of any other mammal; and it may be added that he is also disclosed by almost every relic of his contemporaries—their jaws have, through his agency, lost their condyles and lower borders; their bones are fractured after a fashion known by experiment to be his; and the splinters into which they are broken are deeply scored with his teeth-marks. His presence is also attested by the abundance of his droppings in every branch of the cavern. In short, Kent's Hole was one of his *homes;* he dragged thither, piecemeal, such animals as he found dead near it; and the well-known habits of his representatives of our day have led us to expect all this from him. When, however, we turn to the breccia, a very different spectacle awaits us. We meet with no trace whatever of his presence, not a single relic of his skeleton, not a bone on which he has operated, not a coprolite to mark as much as a visit. Can it be doubted that had he then occupied our country he would have taken up his abode in our cavern? Need we hesitate to regard this entire absence of all traces of so decided a cave-dweller as a proof that he had not yet made his advent in Britain? Are we not compelled to believe that man formed part of the Devonshire fauna long before the hyæna did? Is there any method of escaping the conclusion that between the era of the Breccia and that of the Cave-earth it was possible for the hyæna to reach Britain?—in other words, that the last continental state of our country occurred during that interval? I confess that, in the present state of the evidence, I see no escape; and that the conclusion thus forced on me compels me to believe also that the earliest men of Kent's Hole were *interglacial*, if not *preglacial*.

The following table will serve to show at one view the coordinations and theoretical conclusions to which the facts of Kent's Cavern have led me, as stated briefly in the foregoing remarks. The table, it will be seen, consists of two divisions, separated with double vertical lines. The first, or left hand, division contains three columns, and relates exclusively to Kent's Cavern, as is indicated by the words heading it. The second, or right hand, division is of a more general character, and shows the recognized classification of well-known facts throughout western Europe. The horizontal lines are intended to convey the idea of more or less well-defined chronological horizons, and their occasional continuity through two or more columns denotes contemporaneity. Thus, to take an example from the two columns headed "Archæological" and "Danish-Bog," in the second division: the horizontal line passing continuously through both, under the words "Iron" and "Beech," is intended to suggest that the "Iron Age" of Western Europe and the "Beech" zone of the Danish Bogs take us back about equally far into antiquity; whilst the position of the line under the word "Bronze" indicates that the "Bronze age" (still of Western Europe) take us back from the ancient margin of the Beech era, through the whole of that of the Pedunculated Oak, and about half-way through the era of the Sessile Oak; and so on in all other cases.

KENT'S CAVERN.			PERIODS.				
Deposits.	Bones.	Implements.	Archeolog'al.	Danish-Bog.	Biological.	Geograph.	Climat
Black Mould.	Ovine.	Iron.	Iron.	Beech.	Recent.	Insular.	Post-Glacial
		Bronze.	Bronze.	Pedunculated Oak.			
		and (?)		Sessile Oak.			
		Neolithic.	Neolithic.	Scotch Fir.			
Granular Stalagmite.	Hyænine.	Paleolithic Flakes.	Paleolithic.		Pleistocene.	Continental.	Glacial and (?) Inter-Glacial
Black Band.							
Cave-earth.							
Crystalline Stalagmite.	Ursine.	Paleolithic Nodules.				Insular.	
Breccia.						Continental.	Pre-Glacial

ART. XLV.—*Is the Existence of Growth-rings in the Early Exogenous Plants proof of Alternating Seasons?* An extract from a paper read before the N. Y. Academy of Sciences, March 19, 1877; by CHARLES B. WARRING, PH.D.

WE are told that there must have been the same alternation of seasons before the Glacial Epoch as now, because the exogenous plants of those early times exhibit concentric growth-rings; and consequently the earth's axis must then have been inclined as at present.

But are seasons necessary to the formation of the rings? Until that is established their existence has no importance in this connection. Were it possible in some way to secure a temperature uniform through the year we might be able to determine the question experimentally. The nearest approach to such a condition in this latitude is to be found in green-houses.

The results thus far show that exogenous plants, e. g., the orange and lemon, so placed, form growth-rings as regularly as do the forest trees.

It would be interesting to know how generally exogenous plants in tropical regions exhibit these markings, and whether they are annual or whether they are made at longer or at shorter intervals. I have found it difficult to obtain any information on this point, either from books or from botanists. The latter tell me (I have applied to several botanists of distinction) that they know very little about it. Dr. Gray says, "I know of no exogenous tree that grows continuously. * * * Yet there are exogenous woody stems which do not make annual layers. There is a woody *Phytolacca* which makes more layers, at least twice as many, as it is years old—probably indicating two periods of growth and rest." To this I add that there now lies before me a section of *Chenopodium album* cut on the first of August, and consequently not more than four months old, in which are eight well defined rings. This section is as hard and compact and as well formed wood as if it were a section of ash or pine.

On the other hand there are exogens growing even in this climate, which, notwithstanding our cold winters and hot summers, show not the slightest trace of a ring. I have before me a section of *Akebia quinquefolia* cut by Dr. O. R. Willis on his own lawn from a plant five years old, which has no such markings. Then from a little further south I have a section of the Passion Vine in the same condition; also one of the Iron Wood (*Carpinus Americana*) which presents the faintest possible traces of them. For these also I am indebted to Dr. Willis.

Miss C. C. Haskell, of Vassar College, states the result of her examination of the tropical woods in their museum, as follows: In the *Moria atiara* of the Amazon, the circles are very apparent. In the *Aliso* or *Birch of the Indus*, the circles are evident. They are seen, too, in the *Brazilian Red-wood* (Upper Amazon), and in *Siphonia elastica* or Rubber tree, as well as in the *Moria peranya* of the Rio Negro. None are seen in the *Tortoise Shell Wood* or in the *Cow Tree*."

These suffice to show that, in the uniformly warm climate of the tropics, rings are formed as regularly as in the trees of our northern forests. But it may be said that although there is in these regions no alternation of hot and cold seasons, yet that they do undergo semi-annual changes from wet to dry, and from dry to wet, and that, these being dependent upon the earth's axial inclination, we are not at liberty to infer that the rings would have been formed had there been the absolutely seasonless condition which a perpendicular axis would produce. But there is evidence that exogenous trees would form these marks in a climate of absolutely no variation. I have before me a section of *Mangrove* also presented by Dr. Willis. This tree, as is well known, grows in the muddy margins of tropical rivers and all along the shores, forming dense forests even at the verge of the ocean and below high-water mark. In such a locality there can be no alternation of wet and dry seasons, and the changes of annual temperature must be less than the diurnal. It would seem impossible to conceive of greater uniformity of temperature and moisture, yet this tree presents the growth rings as broad and as well defined as those which are seen in any trees anywhere.

To dispel any vestige of belief that seasons and these markings are connected as cause and effect, I add that the *Cycads* require several years to form one ring.

The consideration of these facts leads to the conclusion that these circles have their origin in cycles of activity and repose, implanted in the constitution of the plant, which would continue to manifest themselves although there were no climatic variations—a conclusion strengthened by the experience of all who have attempted, by artificially equalizing the temperature, to make their plants bloom all the year. It is true that where seasonal variations exist, the successive stages of activity and rest are for obvious reasons synchronous with them, but they are not absolutely dependent upon them.

We may conclude, too, that the pre-glacial flora exhibited similar cycles of growth and rest, some of which may have been of short duration, measured perhaps by weeks, like those of the *Chenopodium*, while others like the *Cycads* may have required several years for their completion.

The following propositions appear to be established by the facts which have been presented.

1. Some exogens form rings at intervals much less than a year.
2. Others require intervals of several years.
3. Some form no rings.
4. The presence or absence of rings in exogens occurs in all climates.
5. Large and well defined rings are found under conditions in which there is absolutely no appreciable variation of temperature or moisture throughout the year.
6. An exogen naturally forming rings, will continue to form them although the climate become uniform through the year.

The existence, therefore, of these markings in the ancient flora gives no information as to the existence at that time of seasons, and so far as they are concerned we are left free to adopt any conclusion as to the inclination of the earth's axis which may appear to us most reasonable.

ART. XLVI.—*On Sipylite, a new Niobate, from Amherst County, Virginia;* by J. W. MALLET.

THE allanite found in Amherst County in this State, of which an analysis by Mr. J. A. Cabell, was published in the Chemical News, 1874, p. 141, occurs in large quantity, and furnishes an abundant source of supply of the cerium family of metals. In picking over a lot of three or four hundred pounds of it, I was struck with the appearance of a few fragments of an accompanying mineral, which on more careful examination turns out to be a new niobate.

The locality in question is on the northwest slope of Little Friar Mountain, about fifteen miles from the Virginia Midland Railway. The allanite is said to occur in a vein of more or less decomposed feldspar in a gneissoid rock, and is met with in large, but very imperfect crystals, and loose lumps of irregular shape, about four feet below the surface of the ground. Magnetite is found with it, the two minerals often forming parts of the same mass; and in going down the vein seems to become more compact, and tends to pass into solid magnetic iron ore. The vein is said to be about two feet wide, and runs about northeast and southwest, dipping at a large angle to the southeast.

Beside allanite, magnetite, and the new mineral now to be described, I have only noticed among the specimens which have reached me a few large crystals of hydrous zircon. One of these measured about 30×18×13 mm., was doubly terminated, of sp. gr.=4·217, and yielded on ignition 1·89 per cent of water.

The new mineral is decidedly rare; all the specimens I have collected were picked out from three lots of the allanite, two of them of several hundred pounds each, and would probably not weigh half a kilogram; the largest single piece weighs about forty grams; most of the fragments are much smaller. It is found imbedded in, or more commonly adherent to, the outside of the masses of allanite and magnetite, from which it is easily detached.

A few imperfect crystalline faces have been met with, but none of these brilliant, and only two dihedral angles that could be, even in a very rough way, measured with the application of a goniometer; each of these was about 125°, which is not far from $I \wedge I$ of the prism of yttro-tantalite, samarskite, and euxenite. There were observed also a few very imperfect cleavage planes. For the most part the mineral appears in little, irregularly shaped masses, very brittle, and exhibiting small, but distinct, conchoidal, as well as uneven fracture.

The color of the mineral in mass is brownish black, in thin splinters a red brown, like that of dark pine-rosin; one or two small specimens display a gradual passage to a brownish orange, and even a yellow, but whether in these cases the chemical composition remains quite the same, there is not sufficient material to determine. The streak is light cinnamon-brown to pale gray. The luster resinous and pseudo-metallic. In general appearance to the eye the mineral is much like fergusonite from Greenland, euxenite from the neighborhood of Arendal, and samarskite from North Carolina, save that the last named is more distinctly pitchy black. Translucent in thin splinters. Hardness = nearly 6. Specific gravity may be considered = 4·89; one specimen gave 4·887 at 12°·5 C.; another 4·892 at 17°·5.

Heated alone in the ordinary blowpipe flame the mineral cracks, decrepitates, *glows brilliantly* (more brightly, I think, and at a lower temperature than any specimen of gadolinite I have ever seen), becomes pale greenish-yellow and opaque, like many specimens of good blast-furnace slag, and remains quite infusible. In the flame of one of Fletcher's hot-blast blowpipes, before which a stout blowpipe wire of platinum readily melts to a bead, thin splinters are fused merely on the edges. Heated in a closed glass tube, the same decrepitation, glowing and change of color are observed, and water is given off, which condensing on the surface of the tube is found to have an acid reaction, and slightly etches the glass. Fused with borax in the oxidizing flame, the mineral is dissolved, producing a yellow glass, which becomes pale on cooling, and assumes a greener tint in the reducing flame. With microcosmic salt, a yellowish green glass is obtained. Strong boiling hydrochloric acid attacks to some extent the mineral in fine powder, and the partial solution, if boiled with metallic tin and diluted with water, gives the fine sapphire-blue color due to niobium. This partial hydrochloric acid solution, if diluted, contains zirconium enough to brown turmeric paper to an extent quite sensible if a comparative experiment be made with similarly diluted hydrochloric acid alone. Boiling concentrated sulphuric acid decomposes the mineral completely, though somewhat slowly; and the diluted solution gives a blue color on addition of metallic zinc.

The chemical analysis was made, with much care and patience, under my direction by Mr. W. G. Brown, a student in this laboratory during the last winter. The details of the method used are given in a notice of his work in the Chemical News. Tantalum was found to be present, but in such small quantity, certainly less than one-twelfth of the niobium, that a satisfactory separation could not be obtained by Marignac's method. The sp. gr. of the mixed niobic and tantalic oxides was 4·60. By determination of the yttrium and erbium first as oxides and then as sulphates it was found that the mixture contained almost exclusively the latter metal, of which the absorption spectrum is obtainable with great distinctness from the crude solution. Iron and uranium were proved to exist as ferrous and uranous compounds. The following results were obtained:

Nb_2O_5	48·66
Ta_2O_5[*]	
WO_3	·16
SnO_2	·08
ZrO_2	2·09
Eb_2O_3	27·94
Y_2O_3[†]	
Ce_2O_3[‡]	1·37
La_2O_3[§]	3·92
Di_2O_3[‖]	4·06
UO	3·47
MnO	trace
FeO	2·04
BeO	·62
MgO	·05
CaO	2·61
Li_2O[¶]	trace
Na_2O	·16
K_2O	·06
F	trace
H_2O	3·19
	100·48

Throwing together, as Rammelsberg has done in his valuable paper[**] on the natural tantalates and niobates, the acid oxides of niobium, tantalum, tungsten, tin and zirconium, reducing all the basic oxides present to the equivalent amounts of dyad oxides, and leaving out the water, we have from the above figures the ratio,

$$R''O : M^{v}_2O_5 = 221 : 100$$

leading to the formula $R''_3M^{v}_2O_8 \cdot 4\,R''_2M^{v}_2O_7$, or, applying the common phosphate nomenclature, a single atomic group of ortho-niobates with four of pyro-niobates; while samarskite, according to the calculation of Professor O. D. Allen[††] from his analysis, contains one to one, or is represented by the formula

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[*] Ta_2O_5 may be assumed = about 2 per cent.

[†] Y_2O_3 may be assumed = about 1 per cent.

[‡] Cerous oxide, but with Cléve's formulæ and atomic weights for this and the corresponding oxides of lanthanum and didymium.

[§] Containing a trace of Di_2O_3.

[‖] Containing a trace of Ce_2O_3.

[¶] Spectroscopically detected.

[**] Jour. Chem. Soc., March, 1872, p. 189.

[††] This Journal, August, 1877, p. 131.

$R''_3M^{v}_2O_8 \,.\, R''_2M^{v}_2O_7$, and Rammelsberg makes pyrochlore from Fredriksvärn solely the pyro-niobate, $R''_2M^{v}_2O_7$, and fergusonite, tyrite, etc., solely the ortho-salt, $R''_3M^{v}_2O_8$.

If, however, the water be included in the calculation, and considered basic, placing it on an equivalent footing with the dyad oxides we have the ratio,

$$R''O : M^{v}_2O_5 = 311 : 100, \text{ or nearly } 3 : 1,$$

which gives the simple formula of an ortho-salt, $R''_3M^{v}_2O_8$. This I confess I am inclined to think more probable, and, if so, it may be allowable to suppose that the very remarkable glow exhibited by the mineral when heated is connected with the loss of basic water and the change from ortho- to pyro-niobate, as in the well known incandescence of ammonio-magnesian ortho-phosphate at the moment of change by heat to the pyrophosphate of the latter metal.*

Whichever formula be preferred, however, for the mineral now described, it differs essentially from that of any niobate hitherto on record, the one view making it the nearest approach to a simple pyro-*niobate* (since the Fredriksvärn pyrochlore contains largely of titanium) and the other making it an ortho-salt like fergusonite, etc., but one partially acid in character or containing basic hydrogen.

Not on chemical grounds alone, but in several respects as to physical properties, the mineral is new and distinct. Carrying out the fancy of Heinrich Rose, which led him to name niobium from the daughter of Tantalus, and remembering the number and complexity of the natural niobates which have been met with, I propose for this species the name Sipylite, from Sipylus, one of the numerous children of Niobe.

*** It may be worth remarking that from the analysis of Professor Allen (loc. cit.) of Professor J. Lawrence Smith's new mineral, hatchettolite, which accompanies samarskite in North Carolina, water seems to be present in it in definite proportion; and, although Rammelsberg has considered the water found in his analyses of tantalates and niobates as non-essential, and the formula, $R''_3M^{v}_2O_8$, which he has assigned in common to fergusonite, yttro-tantalite, tyrite and bragite, requires that water be excluded, if it be also taken into account his analyses of these minerals lead pretty closely to simple relations as to the extent of hydration (without considering the water basic), making**

Fergusonite, from Greenland (with very little water)—$R''_3M^{v}_2O_8$, or perhaps $2R''_3M^{v}_2O_8 \,.\, H_2O$.

Brown yttro-tantalite, from Ytterby	**$2\,R''_3M^{v}_2O_8 \,.\, 3H_2O$.**
Yellow " " "	
Tyrite	
Bragite	
Gray yttro-tantalite, from Gamle Kararfvet	**$2R''_3M^{v}_2O_8 \,.\, 5H_2O$.**

University of Virginia, Sept. 3, 1877.

ART. XLVII.—*On the Mean Motion of the Moon;* by SIMON NEWCOMB.

FOR some time after the appearance of Hansen's Lunar Tables, it was very generally considered that the theory of the moon, after occupying the attention of the mathematicians and astronomers of every century for two thousand years, was at length complete, and that the motion of that body could now be predicted with entire confidence. That Hansen's computation of the inequalities of short period produced by the sun not only far exceeded in accuracy any before made, but fulfilled all the requirements of modern astronomy, I conceive can hardly be doubted. But in the number of this Journal for September, 1870, I showed that this improvement did not extend to the inequalities of long period in the mean motion. While it was true that Hansen by an empirical term had secured a very good agreement with observations from 1750 to 1860, it was there shown that this agreement had been obtained by sacrificing the agreement before 1750, and that the moon had then begun to deviate from the tables at such a rate that they could not continue satisfactorily to represent the observations. During the seven years which have since elapsed, this suspicion has been entirely confirmed. So far as can be judged by the most recent observations, the error of the tables now exceeds ten seconds, and is increasing at a rate of not less than half a second a year.

Shortly after the publication of the short paper to which I have alluded, it was made a part of my official duty to investigate this question. In accordance with this arrangement, I have aimed at the complete discussion of all recorded observations of any astronomical value before the year 1750. These researches now being brought substantially to a close, so far as the observations are concerned, the object of the present article is to give some account of them, and of their results. The material consists in brief, of every observation of an eclipse or an occultation previous to 1750, which appears to be worthy of confidence, and calculated to throw any light upon the question of changes in the moon's mean motion. The available data may be classified as follows:—

I. Accounts of ancient historians from which it has been inferred that the shadow of the moon passed over certain points of the earth's surface during certain total eclipses of the sun. The celebrated eclipses of Thales, of Larissa, and of Agathocles have been very carefully discussed by Professor Airy in two papers which have appeared, the one in the Philosophical Transactions, and the other in the Memoirs of the Royal Astronomical

Society. After a careful examination of the six or eight eclipses in question, I was led to the conclusion that none of them could be safely relied upon as furnishing data for the error of the Lunar Tables at the times when they were observed. It is impossible, within the limited space of the present article, to enter into any details of the considerations which led me to this conclusion. It may be remarked, however, that among the eclipses in which I can feel but little confidence is the celebrated one of Thales. To prevent misapprehension I may say that I do not deny either that Thales predicted eclipses or that the shadow of the moon passed over Asia Minor, B.C., 585 as indicated by the Lunar Tables, or that a battle was stopped by some real or fancied advent of darkness, as described by Herodotus a century afterward; but I fail to see any good reason for maintaining that the extremely obscure account of Herodotus really refers to the total eclipse in question, or, in fact, to any eclipse whatever. Consequently, while these eclipses may be useful in throwing more or less of evidence on the question of the moon's secular acceleration, I do not think they can be considered reliable enough to be used for determining that quantity.

II. The second class comprises the nineteen eclipses of the moon quoted by Ptolemy in the Almagest, on which he founded his theory of the moon's motion. These eclipses appear to be worthy of some confidence, making due allowance for the very considerable errors of observation with which they are necessarily affected. The mode of treatment was this: from a very careful study of the account of each eclipse as given by Ptolemy, and without any knowledge of how it compared with the tables, I sought to make an estimate, first, of the most probable time of the phase described, and second, of the probable error of that time. These estimates I shall publish without any alteration suggested by the subsequent comparison with the tables. When this comparison was made, it was found that the general deviations of the tabular from the recorded times did not indicate a probable error essentially greater than that estimated, except in two cases.

There are five eclipses in which Ptolemy does not say to what phase the time which he gives refers. It has very generally been considered that in these cases the phase was that of the middle of the eclipse; but in all other cases the time which he gives is that of commencement; and there would be a certain probability in favor of the times where no phase was given being also those of commencement. The errors in question were systematically different from those of the other eclipses, and seemed to indicate that in these eclipses also, the beginning was referred to. Owing, however, to the uncertainty of this entire hypothesis, I judged it best to reject these eclipses entirely, and confine the discussion to the fourteen remaining ones.

Among these fourteen, which, in some cases, include the end of the eclipse as well as the beginning, there was a single one, that of B.C., 382, December 22, which was in contradiction with all the others. The other thirteen all agree in the most remarkable manner in assigning a correction of more than half an hour to the tabular times; while this one indicated a negative correction. This discordance, however, is not the most perplexing circumstance. It happened that this eclipse commenced just before sunrise, and therefore just before the moon set; and if the other eclipses were accurate, this one could not have been seen at all. If this one really was seen, it would almost necessitate a negative correction to the tabular times. We have then this dilemma: either the whole thirteen eclipses recorded by Ptolemy are, with a single exception, half an hour or more in error, or there is some mistake about this eclipse having been actually observed. Deeming the latter the more probable of the two hypotheses, I threw out this eclipse entirely. Of the twelve remaining eclipses, sixteen phases were observed, which were divided into four groups, and the mean result, by weight, of each group was taken. The mean corrections to the tabular times given by the several groups, are as follows:—

Epoch,	-687	$\delta t = +20^m$	$\delta\varepsilon = -11' \pm 4'$	3 phases.
	-381	$\delta t = +50$	$\delta\varepsilon = -27 \pm 5$	3 phases.
	-189	$\delta t = +36$	$\delta\varepsilon = -20 \pm 3$	8 phases.
	$+134$	$\delta t = +30$	$\delta\varepsilon = -16 \pm 4$	3 phases.

III. The next observations in order are the eclipses observed by the Arabian astronomers between the years 829 and 1004, which are published in the work entitled Le Livre de la Grande Table Hakémite, traduit par le C^{en}. Caussin, Paris, 1804. This work is a translation of the Arabic manuscript belonging to the University of Leyden. A few of the observations were known to Tycho Brahe and were published by him in his Historia Cœlestis. As a slight indication of the value of these eclipses it may be remarked that the two or three given by Tycho Brahe furnished the first data from which the secular acceleration of the moon was deduced. It is therefore a singular fact that no comparison of them with modern tables has ever been seriously attempted.

There are, in all, in this book, observations of twenty-five eclipses including thirty-four phases of beginning or ending. They were all reduced and compared with the tables of Hansen. Three of them were so far discordant that they had to be rejected entirely. This ratio of three out of thirty-four will not appear great if we reflect that the manuscript from which the observations were translated, was frequently very difficult to decipher or to translate, owing not only to the fading of the writing, but to the uncertainty of some of the terms which the author used. Besides these three discordant observations, there were two which could not be used because the altitude assigned to the moon at the time of the observation actually exceeded its meridian altitude. Here it was evident that there was something wrong, in recording, transcribing or translating the observation. The general result was that each observation of a phase gave the mean longitude of the moon with a probable error ranging from three to five minutes of arc. The results were divided into three groups, each made by a separate observer or set of observers, and therefore worthy of being considered as entirely independent. The mean result of each of these groups was as follows:—

Epoch, 846	$\delta\varepsilon = -4'.4$
926	$\delta\varepsilon = -1\ .1$
986	$\delta\varepsilon = -4\ .8$

IV. Observations made after the revival of science in Europe and before the invention of the telescope. These observations were made by various astronomers from Regiomontanus to Tycho Brahe. But after a careful and laborious examination of all their observations I could find, I was led to the conclusion that none of them would throw any light on the problem. Before Tycho Brahe the observations were no better than those of the Arabs, while the time elapsed was one half that which has elapsed since the Arabian observations. No doubt the observations of Tycho Brahe are more accurate; but the records are so confused that it is impossible to obtain any definite result from them. In fact they preceded the invention of the telescope by so short an interval that it can hardly be supposed that they would throw much light on the question under consideration, however carefully they had been made. I searched carefully to find whether Tycho Brahe had ever observed an occultation, especially of Aldebaran; but could find no trace of any such observation.

V. Observations of occultations and eclipses made with a telescope but without a clock, the time being determined by the altitude of the sun or of some star observed with a quadrant. This class comprises the observations of Bullialdus and Gassendus, as well as some of the earlier of Hevelius. Bullialdus seems to have been the first one who actually observed the occultation of a star by the moon, but he does not appear to have been a skillful observer. The observations of occultations have the great advantage that the only error to be feared is that of the determination of time, always supposing that the phenomenon was actually seen. The disappearance of the star behind the moon's limb is, in fact, a sudden phenomenon which does not require any measure of distance to be well observed.

VI. Observations of eclipses and occultations made by Hevelius with a very imperfect clock regulated by altitudes taken with a quadrant with pinnules. It is well known that Hevelius would never use a telescope with his quadrant; so that the results to be derived from the observations of this most indefatigable observer do not correspond to the labor which he spent in making them. His observations are much better than those of Gassendus, but far more inaccurate than those made with the telescopic sights.

VII. Observations of Flamsteed at Greenwich, and of the astronomers of the French school, from 1672 to 1750. Flamsteed's observations were published in the Historia Cœlestis. Those of the French astronomers are not only for the most part unpublished, but seem to have been totally forgotten from the time they were made until I was fortunate enough to find them in the archives of the Paris Observatory in 1871. Not only were they wholly unreduced, but in many cases not even the name of the occulted star was given. The reduction of these observations has been the most laborious part of my work. The observers have left no explanations whatever of their mass of observations, and it was necessary to learn this by induction from the observations themselves; and from the calculations scattered here and there through the books. The errors of the instruments and of the clocks had to be investigated from modern data; and the observations have proved to be well worthy of the pains which were taken with them. Thereby, the motion of the moon has been traced back to 1675, an epoch seventy-five years before observations upon it have heretofore been supposed to commence. In the same class with these Paris observations are to be included those of DeL'isle at St. Petersburgh, with which I was furnished by Struve.

The following are some independent mean corrections given by the observations of Bullialdus, Gassendus, Hevelius, Flamsteed, and the French astronomers. The list is incomplete, as the discussion of the solar eclipses has not been finished; but it will suffice for the purposes of the present discussion:—

1621	+ 77″	1661	+ 37″
1630	+ 30	1666	+ 24
1633	+ 53	1680	+ 30·4
1635	+ 55	1682	+ 26·5
1639	+ 23	1715	+ 13·8
1645	+ 51	1725	+ 7·0
1652	+ 38		

The investigation is terminated at the epoch of 1750 so far as the reduction of observations is concerned, because there is reason to believe that Hansen's tables are not greatly in error from 1750 to 1865. We may, therefore, in this preliminary discussion consider the tabular errors zero between these epochs. For the epoch 1875 the correction given by some good observations of occultations is −8″0, a result 1″·7 less than that indicated by the observations at Greenwich and Washington. This discrepancy is quite surprising. It is, however, worthy of remark that Captain Tupman from a discussion of all the meridian observations made in Europe about the time in question obtained a mean result somewhat less than that given by Greenwich and Washington alone. It is well known that Hansen's term depending on eight times the mean motion of Venus minus thirteen times that of the earth is almost entirely empirical, being adjusted so as to satisfy the observations between 1750 and 1850. And since this term fails to satisfy the observations outside of these limits, in fact making the tables worse than they would be without it, it ought to be rejected from the comparison of theory with observation. Its effect upon the ancient results is, however, so small in comparison with the necessary error of the observations that its effect need not be taken into account.

From the individual corrections to the moon's mean longitude which have been given for the modern dates I have sought to obtain by a rough interpolation the actual corrections for every quarter of a century from 1625 to 1725. The general results are shown in the following table, of which I shall explain the several parts:

Table of residual corrections to the several theories of the mean motion of the moon.

	(1)	(2)	(3)	(4)	(5)
Epoch.	Hansen.	H′.	s=8″·8.	s=6″·18.	Δt.
−687	−11′	−11′	+16′	+39′	−70^{m}
−381	−27	−27	− 7	+10	−18
−189	−20	−20	− 4	+10	−17
+134	−16	−16	−·6	+ 4	− 6
846	− 4·4	− 4·4	− 2·4	− 0·2	0
926	− 1·1	− 1·1	+ 0·3	+ 2·1	− 4
986	− 4·8	− 4·8	− 3·8	− 1·3	+ 2
1625	+50″	+33″	+ 6″.1	− 6″·6	+12^{s}
1650	+39	+18	− 6 ·9	−19 ·0	+ 3
1675	+32	+15	− 7 ·4	−18 ·6	+34
1700	+21	+16	− 3 ·6	−13 ·5	+25
1725	+ 7	+16	− 0 ·3	− 8 ·6	+16
1750	0	+19	+ 6 ·4	0 ·0	0
1775	0	+21	+12 ·5	+ 8 ·4	−15
1800	0	+15	+11 ·1	+ 9 ·5	−17
1825	0	+ 2	+ 3 ·0	+ 4 ·4	− 8
1850	0	−11	− 4 ·6	0 ·0	0
1875	− 8	−28	−15 ·8	− 7 ·6	+14

In column (1) we have the mean correction indicated by observations to Hansen's tables of the moon without any modification whatever. In column (2) these corrections are modified by the effect of Hansen's empirical term, so as to show the corrections to the pure theory after this term is subtracted from the tables. If the theory is perfect, these numbers ought to be represented by corrections to the mean longitude and mean motion of the moon and the secular acceleration.

The following are the several corrections given by the method of least squares:

$$\left.\begin{aligned}\delta e &= +19''{\cdot}57\\ \delta n &= -12\ {\cdot}31\\ \delta s &= -\ \ 3\ {\cdot}36\end{aligned}\right\}\text{Epoch, 1700.}$$

The value of the secular acceleration adopted by Hansen is 12″·17. Subtracting the correction it seems that the acceleration to which we are led by observation alone, is 8″·8.

Column (3) shows the outstanding corrections which remain after subtracting the result of the corrections we have just found. It is evident that the theory does not represent the observations, and that the most recent observations indicate a value of the secular acceleration much less than that indicated by the older ones. If we investigate the uniform variation of the acceleration which would best satisfy the whole of the observations, we shall find it to be −0″·9 in a century. The hypothesis of such a uniform variation is, however, too improbable to be admitted; and moreover, it still fails to represent the modern observations, although the ancient ones are thus greatly improved.

In recent times it has been generally considered that the difference between the theoretical acceleration and that given by observations arises from a change in the length of the day. It is worthy of remark that by supposing this change itself subject to variations, all the apparent changes in the mean motion of the moon can be accounted for. This is a hypothesis which I have suggested in former numbers of this Journal, as one by which the changes in question may be explained. Let us now see what the actual variations in the rotation of the earth must be to account for the difference between observation and theory. In the first place, the secular acceleration must be supposed to be uniform and equal to 6″·17. Two epochs at which we may suppose the time given by the rotation of the earth to be correct, being entirely arbitrary, we shall take 1750 and 1850 for these epochs. Having thus formed a theory of the moon's mean motion founded on gravitation alone, column (4) shows the apparent corrections indicated by observation. In column (5) these corrections are changed into time. The times here given are hypothetical errors of the earth's rotation which it is necessary to subtract from the times given by astronomical observations in order to reduce them to a perfectly uniform measure of time. The sign + indicates that the earth is ahead of its mean rotation, and the sign − that it is behind it. For some years past it has seemed to me that this was the most probable hypothesis on which to explain the deviations in question. It was evidently a most unwelcome one; for, granting its truth it would be no longer possible to predict the apparent motion of the moon, since the changes in the rotation of the earth could not be expected to follow any determinate law. It is therefore extremely gratifying to find that the comparisons we have just given lead to the hope that these deviations may, after all, be due to the action of some of the bodies of the solar system. A very cursory examination of the residuals given in column 3 shows that they have apparently a period not very far from 260 years. Now, it is remarkable that this differs very little from the period of Hansen's first inequality, which is 273 years. The question therefore arises whether the deviations in question may not be explained by a change in the constants of this inequality. The result is very surprising. By merely diminishing the argument of Hansen's first inequality by 60° 48′ without changing the co-efficients at all, the observations from 1625 to 1875 may all be represented within the limits of error. In fact, we see that the numbers in column (3) may be very nearly represented by the formula

$$-5''{\cdot}04-10''{\cdot}14\left(\frac{t-1800}{1800}\right)-15''{\cdot}50\cos A,$$

in which we have placed,

$$A=18V-16E-g,$$

V being the mean longitude of Venus counted from the equinox of 1800, E that of the earth counted in the same way, and g the mean anomaly of the moon. The comparison in question is shown in the following tables; the fourth column of which is taken from the corresponding column of the preceding table. The residuals still outstanding are shown in the last column.

Epoch.	A.	Computed terms.	Observ.	Diff.
1625	−47°·0	+2″·2	+6″·1	+3″·9
1650	−14 ·0	−4 ·7	−6 ·9	−2 ·2
1675	+19 ·0	−7 ·1	−7 ·4	−0 ·3
1700	52 ·0	−4 ·5	−3 ·6	+0 ·9
1725	85 ·0	+1 ·2	−0 ·3	−1 ·5
1750	118 ·0	+7 ·3	+6 ·4	−0 ·9
1775	151 ·0	+11 ·0	+12 ·5	+1 ·5
1800	184 ·0	+10 ·4	+11 ·1	+0 ·7
1825	217 ·0	+4 ·8	+3 ·0	−1 ·8
1850	250 ·0	−4 ·8	−4 ·6	+0 ·2
1875	283 ·0	−16 ·0	−15 ·8	+0 ·2

Correcting Hansen's term by this empirical addition, we find that instead of

$$15''\cdot34 \sin (A+30^\circ\cdot2),$$

the value given by Hansen, we shall have

$$15''\cdot3 \sin (A+30^\circ\cdot6),$$

as the result of observation.

As a test of this result, the sum of all the corrections here found to Hansen's tables has been taken and compared with the corrections given in column 1. It is to be remarked in the first place that the diminution of 10″ a century in the mean motion of the moon involves a further correction of $-0''\cdot4$ to the value of the secular acceleration in order that the ancient observations may still, on the average, be best represented. Thus the secular acceleration reduces to

$$8''\cdot4\,;$$

and the total correction to the acceleration of Hansen is

$$-3''\cdot76.$$

We put V_2 for the empirical term of Hansen,

$$21''\cdot47 \sin (8V-13E+274^\circ\ 14'),$$

the existence of which appears to have been entirely refuted by the researches of Delaunay; and T for the time counted in centuries after 1800. Then the total corrections to the tables of Hansen are as follows:—

$$-V_2-1''\cdot14-29''\cdot17\,T-3''\cdot76\,T^2-15''\cdot5 \cos A.$$

The following are the values of these corrections for the principal epochs from 1625 to 1900. The computation and comparison with observation is given so fully that any explanation of the table appears to be unnecessary.

Epoch.	$-V_2$	$-15''\cdot5$ cos A.	$-\ 1''\cdot14$ $-\ 29\cdot17\ T$ $-\ 3\cdot77\ T^2$.	Sum.	Observation.	Diff.
1625	+17″·1	−10″·6	+38″·4	+44″·9	+50″	+5″
1650	21 ·4	−15 ·0	34 ·1	40 ·5	39	−1·5
1675	16 ·9	−14 ·7	29 ·4	31 ·6	32	+0·4
1700	+ 5 ·2	− 9 ·5	24 ·3	20 ·0	21	+1·0
1725	− 8 ·6	− 1 ·4	18 ·6	8 ·6	7	−1·6
1750	−18 ·9	+ 7 ·3	12 ·5	+ 0 ·9	0	−0·9
1775	−21 ·2	13 ·6	+ 5 ·9	− 1 ·7	0	+1·7
1800	−14 ·7	15 ·4	− 1 ·1	− 0 ·4	0	+0·4
1825	− 2 ·1	12 ·4	− 8 ·7	+ 1 ·6	0	−1·6
1850	+11 ·4	5 ·3	−16 ·7	0 ·0	0	0·0
1860	15 ·7	+ 1 ·8	−20 ·0	− 2 ·5	+1·5	+4·0
1870	19 ·0	− 1 ·7	−23 ·4	− 6 ·1	−5·5	+0·6
1880	20 ·9	− 5 ·2	−26 ·9	−11 ·1	----	----
1890	21 ·4	− 8 ·4	−30 ·4	−17 ·4	----	----
1900	+20 ·6	−11 ·2	−34 ·1	−24 ·7	----	----

The only case in which the difference exceeds the possible error of the comparisons is at the epoch 1860. As an explanation of this I can only suggest that the term found by Mr. Neison as due to the action of Jupiter is at that time added to the result of a possible error in Hansen's value of the term which depends upon the ellipticity of the earth. The comparison may therefore be improved when the theory is suitably corrected.

The great question which now arises is this. Is it possible that this correction to the term produced by the action of Venus can really be a result of the attraction of that planet? We are struck by the fact that the proposed change can be expressed by a mere change of the algebraic sign of the constant term of the argument, leaving the value of the co-efficient unchanged. It may therefore be inquired whether it is possible that the sign of this quantity is erroneous in Hansen's formula. This question must be answered in the negative. I have found by an investigation still unpublished, substantially the same result as Hansen; while the researches of Delaunay published in the Connaissance des Temps for the year 1862 show that the approximate expression of the constant term in question, is

$$180°-2h',$$

h'' being the longitude of the node of Venus, which does not differ much from 75°. It is, therefore, a mere chance that the change of Hansen's term can be expressed in this way.

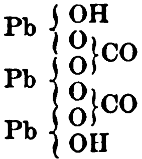
Although Hansen, Delaunay, and myself have all arrived at the same result for the value of the term in question, I cannot confidently say that that result is complete. In all three computations the terms of the second order due to the mutual attraction of Venus and the earth are neglected. It is evident that in consequence of this mutual attraction, the direct action of Venus on the moon is different from what it would be if each planet moved in its elliptic orbit. It may be that this difference is sensible in terms of so high an order as those under consideration. I have actually computed the additional terms in $\frac{1}{\Delta^3}$ (Δ being the distance of Venus from the earth) which arise in this way and which depend upon the argument $18V-16E$. The result is that the values of the several parts which make up this term are quite comparable with those of the elliptic terms which depend on the same argument; but these co-efficients destroy each other in taking the sum. I have, however, always regarded my computations on this subject as incomplete, and have, in consequence, never published them.

As the case stands, the marked agreement between theory and observation which is produced by the introduction of this empirical term, seems to me such as to warrant its provisional use until a more careful investigation of the subject can be made.

Washington, Oct. 3, 1877.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Action of Saline solutions on Lead.*—**Muir** has examined the action exerted by various saline solutions upon lead, with and without access of air, with a view to explain the mechanism of the process. The lead used was sold as pure, and contained only traces of manganese, zinc and iron. Three parallel series of experiments were tried, one in corked flasks, another in beakers covered with paper, and a third in basins, similarly covered. Twenty-five square centimeters of lead were used in each experiment, being placed in a solution of 2·0 gram per liter, of one of the following salts: ammonium nitrate, potassium nitrate, calcium chloride, ammonium sulphate or potassium carbonate, for a time varying from 14 to 21 days. In the corked flask the maximum effect took place in the calcium chloride solution, 1·9 milligrams of lead being dissolved in 14, and 3 milligrams in 21 days; while in the open beaker, ammonium nitrate dissolved from 2 to 4 milligrams, and in the open basin, the nitrate and sulphate each dissolved from 8 to 16 milligrams. The order of solvent power is NH_4NO_3, $CaCl_2$, $(NH_4)_2SO_4$, KNO_3, K_2CO_3. In general, access of air increases the action. The lead deposit formed was a plumbic hydrocarbonate $(PbCO_3)_2$, $Pb(OH)_2$ or 

$$\begin{array}{l}\mathrm{Pb}\left\{\begin{array}{l}\mathrm{OH}\\ \mathrm{O}\end{array}\right.\\ \qquad\quad\Big\}\mathrm{CO}\\ \mathrm{Pb}\left\{\begin{array}{l}\mathrm{O}\\ \mathrm{O}\end{array}\right.\\ \qquad\quad\Big\}\mathrm{CO}\\ \mathrm{Pb}\left\{\begin{array}{l}\mathrm{O}\\ \mathrm{OH}\end{array}\right.\end{array}$$

, in fine silky scales. It was found to be more soluble in ammonium nitrate when air was excluded (one part in 4,600), and in calcium chloride with access of air (one part in 26,000), though its solubility was very great in carbonic acid water (one part in 4,300). The author believes that in the action of saline solutions upon lead, a soluble salt is first produced; that carbon dioxide is slowly absorbed from the air, converting the lead into hydrocarbonate, which is mostly precipitated; that in certain liquids the formation of the soluble salt proceeds at first more rapidly than its precipitation, but that later the latter action preponderates; and that carbonates precipitate the lead salt as fast as it is formed, in the form of hydrocarbonate.—*J. Ch. Soc.*, xxxi, 660, June, 1877. G. F. B.

2. *New Method for the Synthesis of Hydrocarbons.*—**Friedel** and **Crafts**, in examining the action of finely divided aluminum upon organic chlorides, which is at first very slow, but becomes more rapid, found that the aluminum chloride formed in the reaction was the active agent in evolving the hydrogen chloride, remaining itself unaltered. If, for example, amyl chloride be treated with the anhydrous chloride, hydrochloric acid gas is

evolved in the cold, as well as a mixture of gases not absorbable by bromine. In the residue, beside the unaltered Al_2Cl_6, are contained various hydrocarbons, some of high boiling point. If, however, the amyl chloride be mixed with a hydrocarbon, such as benzene in excess, the evolution of gas is regular, and the liquid separates into two layers, the upper one of which is a solution of amyl-benzene in excess of benzene, the lower, one of Al_2Cl_6. Iodides and bromides act similarly, though not as uniformly. Ethyl iodide treated as above gave ethylbenzene, methyl chloride gave toluene (methyl-benzene), xylene (dimethylbenzene) mesitylene (trimethylbenzene) and durene (tetramethylbenzene), benzyl chloride gave diphenylmethane, chloroform gave triphenylmethane and carbon tetrachloride gave tetraphenylmethane. Acid chlorides act in the same way. Benzoyl chloride dissolved in benzene, gives, by the action of aluminum chloride, the ketone benzophenone, acetyl chloride gives acetophenone, phthalyl chloride gives phthalophenone and another product, probably anthraquinone. Further examination showed that zinc and ferric chlorides acted similarly in the cold, ferrous chloride on warming. Copper, cobalt, and magnesium chlorides appeared to be without action. The authors explain the reaction by supposing an aluminum organic compound to be first formed and then decomposed, regenerating the chloride, thus:

$$C_6H_6+Al_2Cl_6=HCl+Al_2Cl_5(C_6H_5)$$

$$Al_2Cl_5.(C_6H_5)+(CH_2C_6H_5)Cl=Al_2Cl_6+(CH_2.C_6H_5)C_6H_5.$$

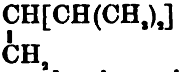
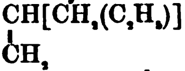
—*J. pr. Ch.*, II, xvi, 233, Aug., 1877. (*C. R.*, lxxxiv, 1392, 1450).

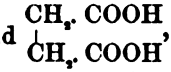
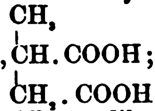
G. F. B.

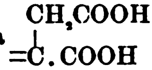
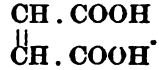
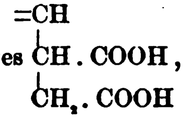
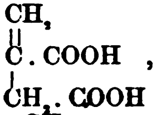
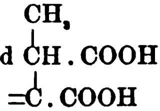
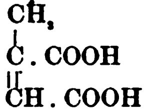
3. *The Terpenes of Swedish Wood Tar.*—ATTERBERG has examined a so-called "wood oil," which is the first product of distillation of the wood tar made in Sweden by the destructive distillation of resinous woods, principally that of *Pinus sylvestris*. The oil was freed from creasote-like bodies and gummy acids by repeated treatment with potassium hydrate, and then submitted to repeated fractioning. In this way there was isolated a terpene boiling at 156·5°–157·5°, and having the properties of australene, and another boiling at 173°–175° having the odor of fresh pine wood, and not identifiable with any other terpene. This the author calls sylvestrene. These two terpenes constitute 80 per cent of the oil. Sylvestrene has a specific gravity of 0·8612 at 16°, is dextrorotatory, rotating +19·5° in sodium light, and forms mono- and di-hydrochlorates, the latter of which recrystallized from alcohol yields broad flat brilliant needles fusing at 72°–73°. Heated in sealed tubes with potassium hydrate, sylvestrene yields an oil having a strong pelargonium odor.—*Ber. Berl. Chem. Ges.*, x, 1202, July, 1877.

G. F. B.

4. *On the Amylene from Amyl Iodide.*—ELTEKOFF has investigated the action of alcoholic potash upon the amylene dibromide obtained from amyl iodide, and concludes that this amylene is really a mixture of two isomeric bodies, isopropylethylene

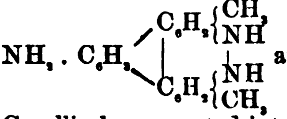

$\begin{array}{l}CH[CH(CH_3)_2]\\ |\\ CH_2\end{array}$ whose bromine derivative gives isopropylacetylene by the action of alcoholic potash; and methylethylethylene 
$\begin{array}{l}CH[CH_2(C_2H_5)]\\ |\\ CH_2\end{array}$ which does not yield valerylene under these circumstances, but is transformed into valeric ether. Isopropylacetylene boils at 35°, forms a crystalline addition product with silver nitrate $AgC{\equiv}C-CH\left\{\begin{array}{l}CH_3\\ CH_3\end{array}\right.$, which is decomposed by iodine, yielding $IC{\equiv}C-CH\left\{\begin{array}{l}CH_3\\ CH_3\end{array}\right.$, moniodisopropylacetylene.—*Bull. Soc. Ch.*, II, xxviii, Aug., 1877. G. F. B.

5. *On the Constitution of unsaturated Dibasic Acids.*—At the close of a series of researches upon certain unsaturated dibasic acids made in his laboratory, FITTIG sums up the results and discusses their bearing upon the constitution of the acids in question; i. e., fumaric and maleic acids in one group, and itaconic, citraconic and mesaconic acids in another. The facts are (1) the two former unite directly with hydrogen to yield succinic acid 
$\begin{array}{l}CH_2.COOH\\ |\\ CH_2.COOH\end{array}$, as the three latter by the same treatment yield the same pyrotartaric acid, 
$\begin{array}{l}CH_3\\ |\\ CH.COOH\\ |\\ CH_2.COOH\end{array}$; (2) the former acids by union with bromine give two different dibromosuccinic acids (both of which, however, are substitution products of ethylene-succinic acid), as the latter give in the same way three different dibromopyrotartaric acids (which must equally be regarded as substitution products of common pyrotartaric acid); (3) the former acids by union with hydrogen bromide yield the same bromosuccinic acid, the latter the same bromopyrotartaric acid, except itaconic acid, which yields an isomer; (4) while mono- or di-brom-citraconic and mesaconic acids lose with great ease on boiling with water or bases a molecule of carbon dioxide, becoming methacrylic or bromomethacrylic acids, probably identical, and easily reduced to isobutyric acid, the corresponding derivatives of itaconic acid are more permanent and yield no carbon dioxide when thus treated; (5) while fumarates and maleates yield on electrolysis the same acetylene, and citraconic and mesaconic acids the same allylene, itaconic acid gives a hydrocarbon not precipitating silver solutions. There is no constitutional formula which will satisfy all these conditions if the position be maintained that in unsaturated compounds the carbon atoms are *always* united by several bonds. Hence the facts compel the adoption of the view advanced by Kekulé, that beside these, there are other bodies, such as carbonous oxide for example, in which there are single carbon atoms whose attractions are not completely balanced. Rejecting also as unproved the existence in a compound of carbon atoms three of whose units are

balanced while the fourth is free, the author gives for maleic acid the formula  $\begin{array}{l} CH_2COOH \\ \vert \\ =C.COOH \end{array}$ and for fumaric acid  $\begin{array}{l} CH.COOH \\ \Vert \\ CH.COOH \end{array}$. For itaconic acid he gives  $\begin{array}{l} =CH \\ \vert \\ CH.COOH \\ \vert \\ CH_2.COOH \end{array}$, or  $\begin{array}{l} CH_2 \\ \Vert \\ C.COOH \\ \vert \\ CH_2.COOH \end{array}$, for citraconic acid  $\begin{array}{l} CH_3 \\ \vert \\ CH.COOH \\ \vert \\ =C.COOH \end{array}$ and for mesaconic acid  $\begin{array}{l} CH_3 \\ \vert \\ C.COOH \\ \Vert \\ CH.COOH \end{array}$. Hence the isobrommaleic acid of Kekulé is properly bromfumaric acid, and the dibrommaleic acid of Bourgoin, dibromfumaric acid. Of the two itaconic acid formulas, Fittig prefers the first.—*Liebig Ann.*, clxxxviii, 95, July, 1877. G. F. B.

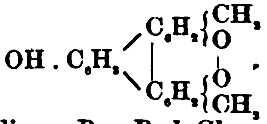
6. *On a Phenol of Phenanthrene, Phenanthrol.*—Rehs has examined, under Graebe's direction, the product obtained by fusing phenanthrenemonosulphonic acid with potassium hydrate. After solution in water, the phenanthrol was separated in oily drops by the addition of sulphuric acid, which solidified on cooling. After boiling with ammonium carbonate, and recrystallization from a mixture of petroleum naphtha and benzene, it was obtained in beautiful blue-fluorescing plates, fusing at 112°, and giving on analysis the formula $C_{14}H_9(OH)$. It forms well crystallized compounds with alkalies, and ethers with acid oxides.—*Ber. Berl. Chem. Ges.*, x, 1252, July, 1877. G. F. B.

7. *Formation of Rosolic acid from Cresol and Phenol.*—The discovery of Caro and Wanklyn that by de-nitrogenizing rosaniline rosolic acid could be formed, and of Dale and Schlorlemmer, that aurin (rosolic acid) could be converted into rosaniline, led Zulkowsky to attempt the production of rosolic acid from cresol and phenol as rosaniline is produced from toluidine and aniline. A mixture of two molecules cresol, one phenol and three of sulphuric acid heated with arsenic acid to 120° C. became dark brown and thick and yielded to water a gummy body with a greenish metallic luster, having all the properties of rosolic acid. It is not produced with phenol alone. The author represents rosaniline as



$$NH_2.C_6H_3\left\langle\begin{array}{l} C_6H_3\left\{\begin{array}{l}CH_3\\ NH\end{array}\right. \\ \vert \qquad \vert \\ C_6H_3\left\{\begin{array}{l}NH\\ CH_3\end{array}\right.\end{array}\right.$$

and rosolic acid as



$$OH.C_6H_3\left\langle\begin{array}{l} C_6H_3\left\{\begin{array}{l}CH_3\\ O\end{array}\right. \\ \vert \qquad \vert \\ C_6H_3\left\{\begin{array}{l}O\\ CH_3\end{array}\right.\end{array}\right.$$

Corallin he separated into five different bodies.—*Ber. Berl. Chem. Ges.*, x, 1201, July, 1877. G. F. B.

8. *A new Coloring matter.*—Hofmann has examined a new brilliant red coloring matter, obtained from Martius. He found it to be the sodium salt of an organic acid, which was separated by concentrated hydrochloric acid. Fine red needles were obtained, easily soluble in alcohol, less so in water, having the formula $C_{16}H_{12}N_2SO_4$, and being monobasic. No doubt, therefore, that

this body was analogous to chrysoidin, and that it could be formed by diazobenzol and naphtolsulphonic acid, by azosulphanilic acid with a naphtol, by azonaphtylaminsulphonic acid and phenol, and by diazonapthalene and a phenolsulphonic acid. Using the first method, and mixing sodium *α* naphtolsulphonate with aniline nitrate and potassium nitrite, the new color was obtained.—*Ber. Berl. Chem. Ges.*, x, 1378, July, 1877. G. F. B.

9. *Examination of a Nickel magnet.*—H. WILD. (Abstract from the original memoir). The author has submitted to examination a nickel magnet presented to Kotschubey, President of the Russian Technological Society, by Jos. Wharton of Philadelphia. It had the form of a flat bar, 2 mm. thick, 9.5 mm. broad, and 155 mm. long, pointed at the ends, and had at its center an agate cap for supporting it on a pivot. Its weight was 25 grams. Its magnetic moment was determined by comparison with a bar of steel of about the same dimensions, and found to be per gram 112,000 units, the steel giving 245,000. After remagnetizing, the nickel gave 188,000, the steel 368,000. With wolfram steel, the moment went up to 594,000 in one instance. The nickel was analyzed by Butlerow and found to contain only one-third of one per cent of iron, with traces of cobalt. The effect of temperature and of time upon the magnetism of nickel was also noted. The following are the conclusions of the memoir: 1st. Pure nickel, unlike pure soft iron, may acquire a considerable amount of permanent magnetism; but the amount of this magnetism, as a maximum, is only from one-half to one-third of that which hardened steel can receive. 2d. The magnetism remaining in the nickel after the magnetizing force ceases, is less permanent than in well hardened steel; the slow loss of magnetism in the course of time, as well as that occasioned by heating and cooling, is proportionally greater than in hardened steel, even when like the steel, it is brought by repeated warming and cooling into a certain condition of permanence. 3d. The temperature-coefficient of a nickel magnet in this condition, is a little greater than that of well hardened steel. 4th. The temporary magnetism which pure nickel assumes is about double that of its permanent magnetic moment, about half of the temporary magnetism which hardened steel can acquire and one-fourth of that capable of being developed in soft iron.—*Bull. Ac. St. Pet.*, xxiv, 1, May, 1877.

10. *Spectroscope with a Fluorescent Eye-piece.*—M. J. L. SORET has published a detailed description of improvements which he has made in the application of the well known properties of fluorescent substances to the observation of the ultra violet portions of the spectrum. He places a screen of the fluorescent material at the focus of the object-glass of the spectroscope, and views the spectrum projected on this screen with an eye-piece placed obliquely, so that the diaphragms and blackened walls of the tube may extinguish the direct rays. As a screen he uses either a small plate of uranium glass or a cell fitted with an aqueous solution of esculine; and the spectroscope is best con-

structed with lenses of quartz and prisms of Iceland spar. With lenses of glass and prisms of flint the spectrum lines could not be distinguished beyond N, but with the spectroscope whose construction he describes in detail the principal lines could be distinguished as far as T. With a more portable spectroscope of similar construction M. Soret has made observations in the Alps at an altitude of 3180 meters, and draws from them the conclusions, that although the ultra violet spectrum is more brilliant at high elevations than on the plains it has no greater extent. In the observations referred to, he could not distinguish rays more refrangible than T. Whence he infers that it is the atmosphere of the sun, and not that of the earth which absorbs the most refrangible rays of the spectrum. The diminution in brilliancy of the more refrangible portion of the spectrum caused by the atmosphere he refers not to the selective absorption of its aeriform constituents, but to the effect of the floating liquid or solid particles, which when more abundant produce a distinct haze or collect in clouds. The general absorption of light due to this last cause affects all the rays of the spectrum, but to a greater extent in proportion as the rays are the more refrangible.—*Ann. Chim. et de Phys.*, V, xi, 72. J. P. C., JR.

11. *Sun's Heat.*—M. A. Crova has published a very extended paper on the calorific intensity of the solar radiation and its absorption by the atmosphere of the earth. In this paper the author discusses very exhaustively methods of observation and gives the results of a large number of measurements which are of great interest, but can not be described in a short abstract.—*Ann. Chim. et de Phys.*, V, xi, 433. J. P. C., JR.

12. *Changes in the Spectra of Gases caused by increasing tension.*—In the spectrum of a gas rendered luminous by an electric spark M. Wullner distinguishes two classes of effects as caused by an increasing tension. In the case of hydrogen only, the bands themselves broaden into a continuous spectrum. With other gases a continuous spectrum appears between the bands which remain meanwhile as definite as at first. In the case of compounds of carbon and markedly in the case of carbonic dioxide the brilliancy of the continuous spectrum soon becomes so great that the bands disappear, but with nitrogen and with air they can be distinguished until the pressure becomes much more considerable. This restatement of the results of previous observations is occasioned by a communication of M. Cazin who refers the continuous spectrum in such cases to the solid particles transported and rendered luminous during the electric discharge.—*Ann. Chim. et de Phys.*, V, xii, 143. J. P. C., JR.

13. "*The Influence of Light in Chemical Changes and chiefly in Oxidation,*" is the subject of a recent paper by M. P. Chastaing. The author distinguishes as a definite effect of the sun's rays the determining of the oxidation of inorganic metallic compounds, an influence which he locates in a different part of the solar spectrum from the well-known reducing action. He deduces this conclusion chiefly from the observation that the oxidation of

such substances as ferrous sulphate, alkaline solution of arsenious acid, and aqueous solutions of hydric sulphide or alkaline sulphides proceeds more rapidly in the light than in the dark, and he endeavors to estimate the action of the light by the difference in the rapidity of the process in the two cases under otherwise like conditions. He concludes that the chemical action of the solar spectrum on metallic compounds both binaries and salts while reducing at the more refrangible end is oxidizing at the less refrangible end. The general reducing action of white light he refers to the circumstance that in the rays as a whole the reducing action is the more powerful of the two. M. Chastaing finds that the green rays still exert a reducing action and he locates between the rays D and E a neutral point of the spectrum, at which chemical action takes place as in darkness. It appears however that the action exerted on organic compounds by the light is quite different from that just indicated. Its influence on such bodies is always oxidizing and this effect continually increases as we pass from the red to the violet end of the spectrum with some variation from this law in the green rays. For numerous details and subordinate conclusions we must refer to the original paper which is quite long but full of interest. We must add that results of our own do not accord, at least *apparently*, with those of M. Chastaing. We have recently discovered in the oxidation of a solution of antimonious iodide under the combined action of the air and light a direct effect of oxidation caused by the sun's rays, and this effect is produced chiefly, if not wholly, by the more refrangible rays.—*Ann. Chim. et de Phys.*, V, xi, 145. J. P. C., JR.

14. *Magnetic rotatory Polarization.*—M. HENRI BECQUEREL has very recently published the results of an important investigation on "Magnetic rotatory Polarization," which is especially interesting as supplementing the researches of his distinguished father on the same subject. His memoir is quite long and the results cannot be stated in a few words. The most important general conclusions are the following:—

(1.) That the positive rotation of the plane of polarization of a ray of light having a definite wave-length, in passing through the unit of thickness of a diamagnetic material under the influence of magnetism, is sensibly proportional to $n^2(n^2-1)$, a function of the index of refraction, and to a factor depending on the magnetism and on the diamagnetism of the body, this factor becoming the greater in proportion as the substances are more diamagnetic. (2.) That with substances chemically allied or containing the same radical the quotient of the magnetic rotation, and the corresponding value of $n^2(n^2-1)$, varies very slightly. (3.) That the chemical nature of the substance exerts an important influence on the phenomenon, and that the several constituents of a compound may produce an independent effect. (4.) That when in solution the specific effect of the molecules of diamagnetic bodies is not influenced by the concentration of the solution, while that of the molecules of magnetic bodies may be greatly affected by the closer proximity, which such a concentration would cause, (5.) That when the substances are very diamagnetic the dispersion of the rays caused by the magnetic rotation is sensibly proportional to $\frac{n^2(n^2-1)}{\lambda^2}$ in which expression λ is the wave length and n the index of refraction. For various qualifications and details we must refer to the original paper, and also for a discussion of the theory advanced by M. Becquerel père, which refers the differences between magnetic and diamagnetic effects to the relative strength of the magnetic energy of the bodies experimented on and that of the medium by which they are surrounded. —*Ann. Chim. et de Phys.*, V, xiii, 5. J. P. C., JR.

15. *Rose-colored Sulphide of Manganese.*—The conditions of the transformation of the rose-colored sulphide of manganese obtained by precipitation into the green semi-crystalline modification of the same compound has been studied by MM. Ph. de Clermont et H. Guiot who come to the conclusion that the two substances are different states of hydration of the same body.—*Ann. Chim. et de Phys.*, V, xii, 111.

16. *Analysis of Alkaline Sulphides and Sulpho-carbonates.*—M.M. Delachanal et Mermet have described a new method for the complete chemical analysis of alkaline sulphides and sulphocarbonates based on the application of hypobromite of potassium as an oxidizing agent. The method offers certain marked advantages and the values obtained indicate that it yields accurate results.—*Ann. Chim. et de Phys.*, V, xii, 88.

17. *Separation of Potassium from Sodium.*—Schloesing has improved and simplified the process proposed by Serullas for separating potassium from sodium based on the circumstance that potassic prochlorate is insoluble in alcohol and that of the radicals most frequently occurring in analytical processes potassium is the only one whose prochlorate does not dissolve in this solvent. He uses for the purpose pure perchloric acid, and gives simple methods for preparing this reagent in the required quantity. Perchloric acid in excess readily replaces both nitric and hydrochloric acid, forming perchlorates of the bases present. Potassic perchlorate is then easily separated and washed with alcohol of forty degrees Baumè. In this process the potassium is weighed as perchlorate after the salt has been heated to 250°, while the sodium is converted into sulphate and weighed as such.—*Ann. Chim. et de Phys.*, V, xi, 561. J. P. C., JR.

18. *A volumetric method of determining the amount of Manganese in iron ores*, is described by M. Garcia Parreño which will undoubtedly be found useful in many cases. The manganese in the ore is at the outset converted into Mn_3O_4 by roasting in a platinum crucible. About a gram is taken for each assay which is dissolved in thirty-five to forty cubic centimeters of hydrochloric acid. The process is conducted in a flask, and the chlorine gas conducted into a weak solution of potassic iodide, the last traces being driven over by boiling the acid. The amount of iodine

thus set free is then determined by a standard solution of hyposulphite of sodium which bleaches the solution colored by the iodine. The solution of the hyposulphite is standardized by a preliminary experiment with pure Mn_3O_4.—*Ann. Chim. et de Phys.*, V, xi, 571. J. P. C., JR.

19. *Light: A series of simple, entertaining and inexpensive experiments in the phenomena of light, for the use of students of every age;* by ALFRED M. MAYER and CHARLES BARNARD. 112 pp. 8vo. New York, 1877, (D. Appleton & Co.).—The purpose of this little volume is to present and illustrate the fundamental phenomena of light in a manner suited to the ready comprehension of the younger class of students, and to suggest means for verifying the laws of its action by actual experiment. The text, which was prepared by Mr. Barnard and revised by Professor Mayer, is written in vivacious and entertaining style, and with such clearness and accuracy of statement that the most inexperienced student cannot fail to understand it. The experiments, which were devised by Professor Mayer, are for the most part new, and have the merit of combining precision in the methods with extreme simplicity and elegance of design. Nearly all the apparatus figured can be made by the young experimenter himself, with the use of the most common and inexpensive materials, and at a very slight expense, the whole cost of the articles required being less than fifteen dollars. The aim of the authors has been to make their readers "experimenters, strict reasoners, and exact observers," and for the attainment of this end the book is admirably adapted. Its value is further enhanced by the numerous carefully drawn and well executed cuts, which add greatly to its beauty. It is to be hoped that many will avail themselves of this opportunity to become practically acquainted with the fundamental principles of Optics. A. W. W.

20. *A Manual of Inorganic Chemistry;* Vol. II. *The Metals;* by T. E. THORPE, Ph.D., F.R.S., Professor of Chemistry in the Yorkshire College of Science, Leeds. New edition, 406 pp. 8vo. New York, 1877, (G. P. Putnam & Sons).—The previous edition of this work, as well as the other volumes by the same author, are well known among chemists, and their value fully appreciated. A feature of this new edition is the collection of examination questions and exercises at the end of the volume.

21. *A System of Volumetric Analysis, by Dr. Emil Fleischer. Translated with notes and additions from the second German edition;* by M. M. PATTISON MUIR, F.R.S.E. 274 pp. 8vo. London, 1877, (Macmillan & Co).—The peculiar merit of this work lies in the fact that it gives not "a complete collection of receipts" for independent processes, but a system of general methods under which the individual cases may be brought. As remarked by the translator the work attempts to divide volumetric processes into a few great groups, to explain clearly the principles underlying each, and further to illustrate by examples the application of these principles. It will be readily seen how much greater benefit the

student will derive from studying this subject, when so systematically presented. We are indebted to the translator for the introduction of the chemical nomenclature and notation of modern chemistry, for some advantageous condensation, and for the addition of more or less new matter.

II. GEOLOGY AND MINERALOGY.

1. *Geological and Geographical Survey of the Territories;* by F. V. **HAYDEN**, U. S. Geologist in charge. Conducted under the authority of the Secretary of the Navy. Washington.—The following are notices of the recent publications of Dr. Hayden's survey, which has been so rich in results to science and the country.

(1.) *Ninth Annual Report, being a Report of Progress for the year* 1875. 810 pp. 8vo, with numerous plates.—This volume contains the following Reports: A letter to the Secretary of the Interior, by Dr. F. V. **HAYDEN** (30 pp.); Geology of the Grand River District, by Dr. A. C. **PEALE** (70 pp.); Geology of the Southeastern District of Colorado, by F. M. **ENDLICH** (134 pp.); Geology of the San Juan Division, by W. H. **HOLMES** (50 pp.); Notes on the Tertiary and Cretaceous of Kansas, by B. F. **MUDGE** (18 pp.). Also Topographical and Geographical Reports by A. D. **WILSON** and F. B. **RHODA**, H. **GANNETT**, G. B. **CHITTENDEN** and G. R. **BECHLER**; and Zoological Reports on the History of the American Bison, by J. A. **ALLEN**; and on the Rocky Mountain Locust and other injurious insects of the West, by A. S. **PACKARD**, Jr. We cite a few facts from some of these reports.

Dr. Peale describes first the topography of his region and then the distribution and characters of the geological formations. These formations include the Archæan, (visible only where the other rocks have been removed), the Carboniferous or Permo-Carboniferous, the Triassic ?, Jurassic ?, and Cretaceous, and also volcanic rocks. Dr. Peale observes that the formations afford evidence of a gradual subsidence of the surface in this part of the Rocky Mountains (the Grand River District), from Pre-Silurian times to at least the end of the Cretaceous, and of no mountain-making era between. "The Archæan area along the northern edge of the San Juan Mountains and south of the Gunnison River probably formed a shore-line in Cretaceous times." "The area of the Archæan Continent was probably of some considerable extent, and the area of this district was probably an extension of that farther east, where the main chain of the Rocky Mountains is now." No Silurian or Devonian beds were observed; and over a great part of the district the red beds (Triassic) rest immediately on the Archæan. The thickness of the Carboniferous in Colorado is stated to be 4,000 to 5,000 feet; and of this only 500 to 1,000 feet consist of fragmental rocks. The accounts of the other formation contain interesting sections and many important details.

Dr. Endlich describes the Sangre de Cristo range and the San Luis and the Huerfano region. The highest mountains of this part of Colorado generally consist, he states, of metamorphic rocks, among which granites and gneisses are the prevailing kinds. Some of them, however, carry sedimentary beds to their summits, as is the case with the Trinchera group, 13,000 feet above the sea-level. The absence of Silurian beds among the unaltered strata in connection with their presence farther east, leads Dr. Endlich to suggest that the metamorphic rocks—granites, gneisses, etc.—may belong to the Silurian and perhaps also the lowest Carboniferous, and he adds, this point is at least "entitled to further investigation." The Carboniferous and Cretaceous rocks are described and various sections are given. The volcanic rocks are spoken of as either trachyte, dolerite or basalt. There are six volcanic areas situated—near the eastern entrance of the Sangre de Cristo Pass; on the Lower Huerfano, constituting small tables; the Spanish Peaks; and a trachytic area near the headwaters of Rio Culebra and Costella. Besides these areas there are numerous dikes. In the chapter on the Sawatch Range, several remarkable examples of erosion are finely represented on the plates, in which beds of trachytic conglomerate are reduced to clusters of slender columns or monuments from 50 to 400 feet in height. An account of the coal beds of the Trinidad region contains results of assays of the coal. Dr. Endlich also discusses the distribution of the Ancient Glaciers of Southern Colorado, and illustrates the subject with a map.

Dr. Holmes describes the geology of the La Plata mining region, giving several well-executed views and sections, and stating many facts of interest connected with the trachytic eruptions. Professor Mudge presents stratigraphical details respecting the Tertiary and Cretaceous beds of Kansas.

The Topographical and Geographical Reports treat of the Grand River District, (including the Uncompahgre valley and plateau,) the San Juan District, the Front Range of the Rocky Mountains, and the Middle and South Parks, giving details of the courses and heights of mountains, systems of drainage, soil and vegetation, and a large amount of information of practical as well as scientific value. Mr. Bechler's Report covers observations for the three years, 1873, 1874, 1875. It contains a general discussion of the mountain systems of the Middle and South Parks, and is illustrated by many outline sketches which are very effective.

The Zoological Report by Mr. Allen, which had previously appeared, has already been noticed in this Journal. Professor Packard's Report treats of a subject of the highest importance to the country—the injurious insects of the west—and occupies 220 pages of the volume. He remarks that in the United States the loss of agricultural products from this source is probably over two hundred millions of dollars each year, and that from one-quarter to one-half of this amount might be saved by preventive measures. Many figures are added to the text illustrating the species.

(2.) *Bulletin of the Survey*, vol. iii, No. 4, pp. 118, 8vo, (739-856 of vol. iii).—This number of the Bulletin contains the following articles: The first discovered traces of fossil insects in the American Tertiaries, by S. H. SCUDDER; description of two species of Carabidæ from Scarboro Heights, by S. H. SCUDDER; Report on insects collected in the explorations of 1875, by P. R. UHLER; on *Cambarus Couesi*, a new craw-fish from Dakota, by T. H. STREETS; on a Carnivorous Dinosaur (*Lælaps trihedrodon*) from the Dakota beds of Colorado, by E. D. COPE; contribution to the Ichthyological fauna of the Green River Shales, by E. D. COPE; on the genus *Erisichthe*, by E. D. COPE.

Mr. Cope states that the fish of the Green River Shales represent families partly of fresh water and partly of brackish or salt water species. Material is needed to decide whether the Green River lake had communication with the sea.

(3.) *Monographs of North American Rodentia*, by ELLIOTT COUES, Assistant Surgeon U. S. A., and J. A. ALLEN, Assistant in the Museum of Comparative Zoology, Cambridge.—This large volume consists of a series of elaborate monographs of the several families of Rodents by Dr. Coues and Professor Allen. Those of the *Muridæ*, *Zapodidæ*, *Saccomyidæ*, *Haplodontidæ*, *Geomyidæ*. by Dr. Coues, and those of the *Leporidæ*, *Hystricidæ*, *Lagomyidæ*, *Castoroididæ*, *Castoridæ and Sciuridæ*, by Professor Allen. Specific and family distinctions, structural relations, geographical distribution past and present, divergences of varieties, and causes or conditions of variation, are among the subjects which come under discussion in this volume, and all the topics are treated with thoroughness and precision. The monograph on the Muridæ is accompanied by four plates. The volume closes with a synoptical list of the fossil Rodents of North America, by Professor Allen, and a Bibliography, by Mr. T. Gill and Dr. Coues.

(4.) *Miscellaneous Publications*, No. 7. *Ethnography and Philology of the Hidatsa Indians;* by WASHINGTON MATTHEWS, Assistant Surgeon, U. S. A. 240 pp. 8vo. Washington, 1877.—This volume, by one who has spent much time with the tribe treated of, contains a full account of the condition, habits, arts, history, etc., of the people, and also a discussion of the relations of its language, together with a grammar and vocabulary.

(5.) *Miscellaneous Publications*, No. 8. *Fur-bearing Animals. A Monograph of North American Mustelidæ;* by ELLIOTT COUES. 348 pp. 8vo, with 20 plates. Washington, 1877.—A work that is thoroughly scientific, while also in part popular in its character.

2. *Fifth Annual Report of the Geological and Natural History Survey of Minnesota, for the year* 1876, N. H. WINCHELL, State Geologist. 248 pp. 8vo. Saint Paul, 1877.—This volume contains reports on the Geology of Houston and Hennepin Counties, with colored maps of each, notes on the Trenton forests of Minnesota; a chemical report by Prof. S. F. PECKHAM; a list of the Fungi of the State, by Dr. A. E. JOHNSON; an entomological

report, treating of the locusts and other insects, by ALLEN WHITMAN.

The report on Hennepin County contains many valuable facts about the drift of the county, and also on the changes from erosion of the Falls of St. Anthony. According to the observations at the Falls from 1680 (by Hennepin) to the present time, the amount of recession is made out to be 906 feet, or, on an average, 5·15 feet per year. At this rate, it would have taken 8,202 years for its recession from Fort Snelling.

3. *The Geological Record for* 1875 *; an account of works on Geology, Mineralogy and Palæontology,* published during the year. Edited by WM. WHITAKER, B.A., F.G.S., of the Geological Survey of England. 444 pp. 8vo. London, 1877.—This second volume of the Geological Record will be welcomed by all who are interested in the progress of geological or mineralogical science. The notices are brief, but yet they are so well prepared as to give a correct idea of the contents of publications. It thus enables the student to survey the year's progress at a glance, and to gather up references to the papers or works which he may need to consult in detail.

4. *Preliminary Notice of the Discovery of a new Mineral Species;* by GIDEON E. MOORE, Ph.D. (Communicated.)—The species here briefly described occurs associated with chalcophanite in ochreous limonite, at the Passaic Zinc Mine, Sterling Hill, New Jersey, and presents the following characters:

In botrioidal coatings of columnar radiate structure, usually coated with a thin layer of chalcophanite.

H.=5 (Mohs's scale); G.=4·933. Luster metallic to submetallic. Color black. Streak brownish black. Opaque. Brittle.

Before the blowpipe: in the forceps unchanged; in the closed tube yields a little water. With fluxes reactions for manganese and zinc.

The analyses lead to the formula $\dot{Zn}$, $\dot{Mn}$, $\ddot{\bar{Mn}}$ or $\dot{Zn}\,\ddot{\bar{Mn}}$. Whence the species is a zinc haussmanite.

From its invariable association with and close genetic relation to chalcophanite, I propose for the species the name *Hetærolite*, from ἑταῖρος, a companion.

Jersey City, Sept. 25, 1877.

5. *On some Tellurium and Vanadium Minerals;* by F. A. GENTH.—Dr. Genth's paper contains descriptions of three new species, whose characters are here given.

Coloradoite. Not crystallized, without cleavage; massive, somewhat granular; sometimes having an imperfectly columnar structure. (Smuggler Mine). Hardness about 3; specific gravity = 8·627 (calculated for the pure mineral). Color iron-black, inclining to gray with a very faint purplish hue; luster metallic; surface frequently tarnished. Fracture uneven to subconchoidal. Composition: HgTe = Tellurium 39·02, mercury 60·98 = 100; all the specimens analyzed were more or less impure, as it was impossible to separate entirely the associated minerals. Found in Colorado at the Keystone and Mountain Lion Mines, with native tellurium and quartz; also at the Smuggler Mine, where it is often mixed with native gold, tellurium and tellurite.

Magnolite. Occurs in exceedingly fine needles, grouped in bundles or tufts, sometimes radiating. Color white; luster silky. Composition: Hg_2TeO_4. Found at the Keystone Mine, Magrolia District, Colorado; it occurs in the upper decomposed portion of the mine, with quartz, limonite and psilomelane, having been produced by the oxidation of coloradoite.

Ferrotellurite. A crystalline coating on quartz, associated with native tellurium; under the microscope it appears in very delicate tufts, sometimes radiating, or in cavities in minute prismatic crystals of a color between straw and lemon-yellow inclining to greenish-yellow. Composition probably $FeTeO_4$; the small quantity in hand did not allow of a reliable analysis. Found at the Keystone Mine, Colorado.

Dr. Genth also mentions the occurrence of *Tellurite* (tellurium dioxide, TeO_2) at the Keystone, Smuggler, and especially at the John Jay Mine, Colorado. It is found in minute white, yellowish-white and yellow crystals, mostly prismatic, isolated or aggregated into bundles. Cleavage eminent in one direction, luster on this face adamantine, elsewhere vitreous inclining to resinous. The same compound was observed by Petz with native tellurium at Transylvania. Native tellurium has been found, according to Dr. Genth, at the Keystone, Mountain Lion and Dun Raven Mines in Magnolia District, Boulder Co., Colorado, also at the Smuggler Mine in Ballerat District, Boulder Co.; hessite, (containing only ·1 per cent gold) has been found at the Kearsarge Mine, Dry Cañon, Utah; calaverite occurs at the Keystone and Mountain Lion Mines, Colorado.

Roscoelite is shown to contain not V_2O_5 (as assumed by Prof. Roscoe), but probably V_2O_3; a related "green mineral" has been found in an impure state in the gangue rock of the mines in Magnolia District, Colorado; it contains, however, more aluminum and less vanadium. An analysis of the Siberian volborthite is given, and its relation shown to the species psittacinite. E. S. D.

6. *Mineralogische Mittheilungen* von G. VOM RATH.—The recent mineralogical memoirs of the eminent crystallographer, Prof. vom Rath of Bonn, contain descriptions of crystals of gold, of a remarkable twin of smaltite, of rutile in the form of hematite from Switzerland, and on compound rutile crystals from Arkansas; the explanation of the obscure crystallization of the plates, and thread-like forms of gold, is an especially valuable contribution, and is elucidated by a considerable number of figures. E. S. D.

7. *Elemente der Mineralogie* von CARL FRIEDRICH NAUMANN. *Zehnte gänzlich neubearbeitete Auflage* von Dr. FERDINAND ZIRKEL. 714 pp. 8vo. Leipzig, 1877, (Wilhelm Engelmann).—The Mineralogy of Naumann has long been the standard work in Germany. The first edition was published in 1846; the ninth edition bears the date October 18, 1873, only a few weeks before the close of the author's long and active career. Fortunately this, his most

important work, did not end with his death, but its continuation has been undertaken by one well fitted to perform the task. The present edition, while including much new matter, retains the form and arrangement of those which have preceded except in one most important particular: the awkward and antiquated system of classification of mineral species employed by Naumann has been replaced by the now generally accepted method based upon their chemical composition. This will be seen to be a most important change for the better, increasing much the value of the work.

E. S. D.

III. Botany and Zoology.

1. *Occurrence of another gigantic Cephalopod on the coast of Newfoundland;* by A. E. Verrill.—A nearly perfect specimen of a large squid, was found cast ashore after a severe gale, at Catalina, Trinity Bay, Newfoundland, Sept. 24. It was living when found. It was exhibited for two or three days at St. Johns, and subsequently was carried in brine to New York, where it was purchased by Reiche & Bro. for the New York Aquarium, where I have had an opportunity to examine it.* Although somewhat mutilated, and not in a very good state of preservation when received, it is of great interest, being, without doubt, the largest and best specimen ever preserved. It proves to be *Architeuthis princeps*, formerly described by me, from the jaws alone, in this Journal.† The jaws agree well in form and color with the large pair there figured, and are fully equal to them in size, being apparently larger in proportion to the body than in *A. monachus*, so that my estimate of the probable size of the body of the former specimen was much too great. The Catalina specimen, when fresh,‡ was 9·5 feet from tip of tail to base of arms; circumference of body 7 feet, length of tentacular arms 30 feet; length of longest sessile arms (ventral ones) 11 feet; circumference at base 17 inches. Length of upper mandible 5·25 inches; diameter of large suckers 1 inch; diameter of eye-sockets 8 inches. The eyes were destroyed by the captors. It agrees in general appearance with *A. monachus*, but the caudal fin is broader and less acutely pointed; it was two feet and nine inches broad when fresh, and broadly sagittate in form. The rims of the large suckers are white, with very acutely serrate margins, and the small smooth-rimmed suckers, with their accompanying tubercles, are distantly scattered along most of the inner face of the tentacular arms, the last ones noticed being nineteen feet from the tips. The sessile arms present considerable disparity in length and size, the dorsal ones being somewhat shorter and smaller than the others; the serrations are smaller on the inner edge than on the outer of the

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* When examined by me it was loose in a tank of alcohol. I learn that it has since been "prepared" for exhibition by a taxidermist, who has inserted two large, round, red eyes close together on the top of the head!

† Vol. ix, p. 181. Plate V, figs. 14, 15, March, 1875.

‡ Measurements of the freshly caught specimen were made by Rev. M. Harvey, at St. Johns, and communicated to me.

suckers. A more detailed description is deferred to a succeeding number, together with a description of another specimen.

2. *The Antelope and Deer of America;* by John Dean Eaton. 8vo, 426 pp., numerous cuts. New York, (Hurd & Houghton.) 1877.—This is an excellent treatise on the prong-horn antelope and the various species of deer, moose and elk, of which eight species are recognized. The descriptions of the species are detailed, and a large part of the book is devoted to their habits, domestication, hybridity, aliment, diseases, the chase, comparisons with congeners, and other kindred subjects. The illustrations are well executed and characteristic. V.

3. *Life Histories of the Birds of Eastern Pennsylvania;* by Thomas G. Gentry. Vol. ii, 8vo, 399 pp. Philadelphia. Published by the author, 1877.—The second volume of this work, which has just reached us, is, like the first, replete with details in respect to the habits of birds, and more especially as to their migrations, the time occupied in building nests and incubating, and the nature of food at different seasons of the year. In this consists its chief scientific value. The author has evidently spent a great amount of time and labor in making and recording observations of this kind. The volumes include all the families above the waders, and the author proposes to complete the work in another volume. V.

4. *Zoologische Wandtafeln;* by Dr. R. Leuckart and Dr. H. Nitsche. Cassel: Theodor Fischer.—We have received three examples (Protozoa, Cœlenterata, Arthropoda) of these lithographic zoological diagrams. They are admirably executed. The figures are large and clearly drawn, and printed in strong colors, so that they are excellently adapted for class rooms of large size. They will thus supply a want that has long been felt by teachers of zoology. The figures have been well selected from the best works, including very recent memoirs. Each diagram is printed in sections, on four sheets, and can easily be mounted on cloth backs. We heartily commend this series to all teachers who are in want of illustrative zoological diagrams. V.

5. *Bulletin of the U. S. National Museum.* Department of the Interior.—Numbers 7, 8 and 9 of this Bulletin have recently been issued. No. 7 contains contributions to the Natural History of the Hawaiian and Fanning Islands and Lower California, by T. H. Streets, M.D., 169 pp. 8vo, 1877; No. 8, Index to the Names which have been applied to the subdivisions of the Class Brachiopoda, by W. H. Dall, 88 pp. 8vo, 1877; No. 9, contributions to North American Ichthyology; No. 1, by David S. Jordan, 54 pp. 8vo, 1877.

6. *Notes on some Common Diseases [of plants] caused by Fungi;* by W. G. Farlow. Bulletin of the Bussey Institution, vol. ii, part 2, 1877.—Leaving to another department of the Journal to notice the interesting papers on the composition of pumpkins and squashes, the analyses of certain seeds occasionally used for human food, and two or three other papers by Prof. Storer which this new number

of the Bussey Bulletin contains, we call attention here only to Prof. Farlow's short article, which refers to some of the various questions and problems he has had to deal with during the past year. They mainly relate to the Black Knot of Plum trees, which was the subject of a former paper; to the American Grape-vine mildew (*Peronospora viticola*), and a disease caused by *Uncinula spiralis* the conidial form of which is practically undistinguishable from the notorious *Oidium Tuckeri;* to the *Fumago* of Orange and Lemon trees, in which it appears that the mischief produced is owing to a wooly plant-louse, upon the excretions of which, or the exudations of the leaf caused by the punctures, the fungus is thought to live; and, finally, there are some notes supplementary to Prof. Farlow's memoir on the Onion-smut. It seems that this *Urocystis Cepulæ* of Frost is not peculiar to the United States, but is to all appearance the same as *U. magica*, found on an Italian *Allium* in Italy. "A careful examination of the wild species of Onion growing in our own country should be made by fungologists, for it seems highly probable that the fungus which does so much injury to cultivated onions will also be found on the wild species." It is well that we have in this country an institution which furthers investigations of this sort, and intends to educate a generation of teachers capable of undertaking them. A. G.

7. *Flora Brasiliensis.*—The 70th fascicle, a large one, with 70 plates, is filled with Bentham's elaboration of the *Mimoseæ*, and concludes the sixteenth volume. The 71st contains the small orders, *Ochnaceæ*, *Anacardiaceæ*, *Sabiaceæ*, and *Rhizophoraceæ*, by Dr. Engler. As to *Ochnaceæ*, the author confirms Planchon's idea, announced in 1862 but not anywhere acted upon, that this order embraces *Sauvagesia;* and he insists that it is allied to *Dilleniaceæ* and not to *Rutaceæ*. For the large genus of the order, Engler, following Baillon, replaces Schreber's long received name of *Gomphia* by *Ouratea* of Aublet, and he appears to have seen and identified Aublet's original specimens. In *Anacardiaceæ* the genus *Lithrea* of Miers is reinstated. Brazil has but one species of the order *Sabiaceæ*, and only one Mangrove. Fascicle 72, which is rather large, continues the Grasses and includes the tribe *Paniceæ*. The editor, Dr. Dœll, describes 156 Brazilian species of *Panicum* (keeping *Helopus* distinct) and 105 of *Paspalum*. A. G.

8. *Botany of British Columbia and Northern Rocky Mountains.*—In the *Report of Progress* of the *Geological Survey of Canada for* 1875–76, issued in 1877, we find an interesting narrative, by Professor John Macoun, of a botanical exploration from Victoria to the Peace and Athabasca Rivers east of the Rocky Mountains, and thence to Canada, to which is appended a full Catalogue of the Plants collected, or known to Mr. Macoun to occur on this range, with a careful indication of their geographical distribution across the continent. A very useful and important paper. A. G.

9. *Sketch of the Vegetation of the Nicobar Islands; Enumeration of Burmese Palms; Contributions toward a knowledge of the*

Burmese Flora, etc.; by S. KURZ.—These are the titles of some of the principal papers recently contributed by Dr. Kurz to the Journal of the Asiatic Society of Bengal, which we have received, and which seem not to be as well known as they deserve to be. Besides critical systematic work, there are interesting observations upon the kinds and characteristics of tropical forests, etc. The subjoined note may be a caution to those who collect native names. "*Petal* occurs as a name for several different plants in Jelinck's journal. I fear it is meant for '*bétúl*' ('*just so*,' '*right so*'), a very usual reply of a Malay to a question regarding the pronunciation of a word." A. G.

10. *Arboretum Segrezianum* . . . par ALPH. LAVALLÉE.—This handsome octavo volume, as its full title declares, is an enumeration of the trees and shrubs cultivated at Segrez (Seine and Oise), including their synonymy and their origin, with references to the works in which they are figured. It is published by Baillière, is edited with much care (yet not to the avoidance of sundry mistakes and misprints in other than French names, etc.), and is beautifully printed. It represents a great amount of conscientious work while the author was forming the Arboretum which now adorns his paternal estate, and which bids fair to be one of the very best in France, although as yet only twenty years old. The catalogue is prefaced by some notice of its formation, and of the origin and condition of several of the older French collections. Among the difficulties encountered, that of nomenclature was foremost and greatest, the same tree coming to him under various different names, and different trees under the same name, sometimes through traditional errors or oversights of the nurserymen, sometimes through less innocent practices of "*quelques horticulteurs*," which our author is constrained to denounce. In consequence he was obliged to study up the nomenclature and arrange the synonymy for himself throughout, with the best aid to be had from the *Jardin des Plantes* and elsewhere. Hence the *raison d'être* of this volume, and its value to all who have similar collections to make, or to care for. A. G.

11. *Systema Iridacearum*; by J. G. BAKER.—This begins in the 90th number of the Journal of the Linnean Society, and is continued in the following. When concluded, we may give an abstract of the portions which relate to North American botany. Mr. Baker's work upon the monocotyledonous orders has been useful and timely, and the *Iridaceæ* particularly need revision, having been almost untouched by all later systematists, except by Dr. Platt, whose synopsis in the Linnea is far from complete, being founded mainly upon the materials in the Berlin herbarium, and whose views are not always to be adopted. A. G.

12. *Native "Artichokes."*—Upon reading the article upon *Helianthus tuberosus*, contributed to this Journal (in May last) by Messrs. Trumbull and Gray, the well-known Canadian botanist and explorer, Mr. John Macoun, wrote as follows:

"It is a fact that a species of *Helianthus* which I took to be *H.*

tuberosus, grows in abundance in the valley of the Kaministiknia, on the right bank of the river, above Point Memon. This river discharges into Thunder Bay, Lake Superior, and is quite easy of access from the United States. I saw the plant growing in abundance on the alluvial flats on the 12th July, 1869, and found the tubers of a large size at that time. Whether my plant is the true tuberosus or not, it is certainly the parent of the Indian tuber. Where I got it was on the old (high) road to the northwest. It would be worth while to have one of the American tourists get a few plants late in August. I have no doubt but I have hit upon the exact locality from which the French took the tubers, and it only remains to identify my plant with *H. doronicoides*."

It is well to know of this station; but the Hurons of Sagard's narrative doubtless dwelt much farther east.

Dr. C. C. Parry has directed our attention to his list of plants of Wisconsin and Minnesota, published in Owen's Geographical Survey of Wisconsin, Iowa and Minnesota, in which, on page 614, is the entry: "*Helianthus tuberosus* L., Common Artichoke, river banks, St. Peter and St. Croix, certainly native, and a well-known article of diet among the Indians, called by the Chippewas Ush-ke-baug." An original specimen was kindly supplied by Dr. Parry, of which at this moment we can only say that it does not belong to *Helianthus tuberosus*. Thus there appears to be a second edible tuberiferous *Helianthus*, of which a further knowledge is a desideratum.

In regard to the other sort of root mentioned by Sagard as resembling parsnips, "which they call *Sondhratates*, and which are much better," Dr. Macoun is confident that not *Sium lineare* but *Aralia racemosa* is meant: for the older inhabitants of that part of Canada affirm that the root of this *Aralia* was a favorite food of the Indians, and that they taught its use to the first settlers. In flavor this root (commonly called "spikenard" and "spignet") might well be said to resemble parsnips. A. G.

13. *Necrological.*—There have died during the past summer two European botanists of note, namely, HENRY A. WEDDELL and PHILIP PARLATORE; notices of whom will be given in the obituary record of the year. A. G.

IV. ASTRONOMY.

1. *Discovery of a New Planet;* by C. H. F. PETERS. (From a letter to the editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Oct. 15, 1877.)—I take pleasure in forwarding an observation of a new planet found last night, showing the brightness of a star of 10·5 magnitude:

Oct. 14. 12h 39m 51s H. C. m. t. $\alpha(175)=1\text{h}\ 6\text{m}\ 4.73\text{s}.$ $\delta(175)=+8°\ 6'\ 37{\cdot}4''$,

from 18 comparisons with Schj. 397. The daily motion of the planet is about 36^s in right ascension, and between 13′ and 14′ in declination toward the south. You are perhaps already aware, that the planet, of which the last number of the Journal contains a valuable series of observations with the number (174), is identical with the planet (141) *Lumen;* so that what is called there (175), receives the former, and the present planet the latter number.

2. *Comets in* 1877.—The number of comets for the present year already amounts to six. 1. Discovered by Borrelly, Feb. 8th. 2. Discovered by Winnecke, April 5th. 3. Discovered by Swift, April 11th. 4. Discovered by Coggia, Sept. 13th. 5. Discovered by Tempel, Oct. 2. To these is to be added d'Arrest's comet of short period.

3. *Observations and Orbit of Tempel's Comet.*—Comet *b*, 1877, discovered by Tempel October 2d, was first seen at the Observatory of the Sheffield Scientific School October 5th. From measurements made on the 5th, 7th and 9th, the following provisional orbit has been computed. The comet is receding from both the earth and sun, and will soon disappear. From places computed for August 1st and September 1st it appears that the comet must have been in reach of the telescope for a time after evening twilight as early as July, and has been ever since that time both favorably situated for observation and at least as bright as when discovered. It cannot have approached us at any time nearer than about ·8 of the earth's radius vector. These elements show no marked resemblance to those of any previously calculated orbit. The observations were made and orbit computed by Mr. W. Beebe and Mr. H. A. Hazen.

New Haven m. t.		Comet's α (m. eq. 1877·0).	Comet's δ.
	h m	h m s	
Oct. 5,	10 30·7	23 39 12·7	−13° 50′ 9″
7,	9 48·3	32 31·0	15 40 47
9,	9 25·2	26 29·1	17 20 58
11,	7 45.4	21 7·7	18 48 53

T=1877, June 26·800 Wash. m. t.

$$\left.\begin{array}{l}\pi = \ \ 80^\circ\ 43'\cdot2\\ \Omega = 184\ \ 17\ \cdot9\end{array}\right\}\text{m. eq. } 1877\cdot0$$

$i = 115\ \ 54\ \cdot0$

log. $q_{,} = \cdot031956$

C.—O.

	$\Delta\alpha$	$\Delta\delta$
Oct. 7,	$-\cdot1^s$	$+\ 2''$
11,	$-\cdot9$	$+38$

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Proceedings of the Davenport Academy of Natural Sciences.* Vol. ii, Part 1. Jan., 1876 to June, 1877. 148 pp. 8vo.—The Davenport Academy publications are especially rich in papers on American Archæology. The number of the Proceedings before us contains several papers of this character by the following authors: W. H. Pratt, Rev. J. Gass, R. J. Farquharson, M.D., Rev. S. D. Peet, C. T. Lindley and Julia J. Wirt.

Mr. Gass announces the discovery of three engraved tablets in an Indian mound, which he calls "Mound No. 3 of the Cook's Farm Group;" and these are particularly described by Mr. Farquharson in a paper illustrated by excellent photographs of the tablets. One represents a calendar, another a sacrificial or cremation scene, and the third a hunting scene. In the last, thirty individuals are represented: of man, 8; bison, 4; deer, 4; birds, 3; hares, 3; big-horn or Rocky Mountain goat, 1; fishes, 1; prairie wolf, 1; non-descript animals, 3. One of the last three it is suggested may be the Mastodon, and hence, and in view of other published announcements, the cotemporaneity of Man and the Mastodon is deemed probable. The number contains also a few zoological papers by J. D. Putnam.

2. *U. S. Geographical and Geological Survey of the Rocky Mountain Region.* J. W. POWELL, Geologist in charge. Department of the Interior.—This survey, under the Interior Department, has recently issued volume I of *Contributions to North American Ethnology*, a quarto volume of 362 pages, with many illustrations. Part I contains a Report on the tribes of the extreme Northwest; by W. H. DALL; Part II, on the tribes of Western Washington and Northwestern Oregon, with a map, by GEORGE GIBBS, including, in an appendix of 122 pages, comparative vocabularies, and a Niskwalli-English and English-Niskwalli Dictionary.

3. *Burial Customs of North American Indians;* Mr. H. C. YARROW, of Washington, D. C., has issued a circular requesting information in aid of a memoir he is preparing, upon the "Burial Customs of the Indians of North America, both ancient and modern, and the disposal of their dead," and to this end invites attention to the following points in regard to which information is desired: Name of the tribe; locality; manner of burial, ancient and modern; funeral ceremonies; mourning observances, if any. The material obtained will be published under the auspices of Major J. W. Powell, in charge of the U. S. Geographical and Geological Survey of the Rocky Mountain Region. Communications may be addressed to Mr. Yarrow, 1747 F St., Washington, or at the Army Medical Museum, Washington, D. C. The circular contains more detailed statements.

4. *On the Science of Weighing and Measuring and Standards of Measure and Weight;* by H. W. CHISHOLM, Warden of the Standards. 192 pp. 8vo. London: 1877, (Macmillan & Co. Nature Series).—This little volume contains a very interesting account of the ancient standards of weight and measure, more particularly those of England; it also describes the methods employed in the restoration of the imperial pound and yard after their destruction by the burning of the Houses of Parliament in 1834. Another chapter is devoted to the Metric System, and one also to instruments for weighing and measuring. The numerous illustrations of the ancient standards add much to the interest of the description.

5. *How to draw a Straight Line; A Lecture on Linkages;* by A. B. KEMPE, B.A. 51 pp. 8vo. London, 1877, (Macmillan & Co. Nature Series).—A description of the ingenious systems of linkages with which it is possible to draw a straight line, to trisect an angle, and to solve other geometrical problems.

6. *The Elements of Descriptive Geometry, Shadows and Perspective, with a brief statement of trihedrals, transversals, and*

spherical axonometric and oblique projections. For colleges and Scientific Schools; by S. EDWARD WARREN, C.E. 282 pp. 8vo. New York, 1877, (John Wiley & Sons).—A valuable work for students in descriptive geometry. It is intended as a concise text-book, and is rendered more useful in this work by the addition of numerous examples in connection with the successive problems.

7. *Smithsonian Report for* 1876.—Many are the ways in which the Smithsonian Institution is promoting the progress of science in the land. One among these, of very wide influence, is the publication, in its Annual Report, of an appendix containing memoirs on scientific subjects. Among the memoirs in the Report for 1876 there are the following:

Eulogy of Guy Lussac, by M. Arago; a biographical sketch of Dom Pedro II, by A. Fialho; a paper reviewing the kinetic theories of Gravitation, by W. B. Taylor; on the Revolutions of the Crust of the Earth, by Prof. G. Pilar, of Brussels; on the Asteroids between Mars and Jupiter, by D. Kirkwood; and various Ethnological papers, relating mostly to American relics. One of the papers, that on the Latimer Collection of Antiquities (from Porto Rico), now in the Smithsonian Museum, by O. T. Mason, is illustrated by sixty figures; and another, on Mounds in Wisconsin, by M. Strong, by five figures or diagrams.

RECEIVED TOO LATE FOR FURTHER NOTICE HERE.

Palæontology of the Geological Survey of the State of New York: Illustrations of Devonian Fossils, Gasteropoda, Pteropoda, Cephalopoda, Crustacea, and Corals of the Upper Helderberg, Hamilton and Chemung Groups; by JAMES HALL. Published in advance of the Palæontology of New York, by authority of the Legislature of the State of New York, nearly 150 plates, 4to. Albany, 1877.

Twenty-eighth Annual Report of the New York State Museum of Natural History, by the Regents of the University of the State of New York (ex-officio Trustees of the Museum). Transmitted to the Legislature March 30, 1875; containing a paper by James Hall, consisting of 34 plates of fossils of the Niagara group of Central Indiana with explanations, and important papers on Trilobites, etc., by C. D. Walcott, with a Botanical Report, by C. H. Peck.

OBITUARY.

URBAN J. J. LEVERRIER, the French astronomer, died on Sunday, the 23d of September, at the age of sixty-six, having been born on the 11th of March, 1811.

JOHN G. ANTHONY, the conchologist, Professor in Harvard College, Cambridge, Mass., died on the 9th of October, aged seventy-three years. He was born in Providence, Rhode Island, May 17, 1804.

BENJAMIN HALLOWELL, author of a work on Geometrical Analysis, died at Nair Hill, Montgomery County, Maryland, in his seventy-eighth year.

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[THIRD SERIES.]

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ART. XLVIII.—*On the Proper Motion of the Trifid Nebula:* M. 20 = H. v; 10, 11, 12 = h. 1991, 3718 = G. C. 4355.

[R. A. = $17^{h}\ 53^{m}\ 51^{s}\cdot8$, N. P. D. = $113^{\circ}\ 1'\ 39''\cdot9$; 1860·0];

by EDWARD S. HOLDEN.

[Read in Abstract to the American Association for the Advancement of Science.]

IN a paper in this Journal for May, 1876, on the supposed changes in the Nebula M. 17, I said (p. 360): "A remarkable instance of proper motion of this latter kind is that of the *Trifid Nebula* G. C. 4355, which has moved since 1833 so that the remarkable triple-star which was then quite clear from the nebulosity in a dark space formed by the junction of the three dark channels, is now by the evidence of Lassell (1863) Winlock and Trouvelot (1874) and myself (1875) well involved, the motion being confirmed by Herschel's drawing at the Cape of Good Hope (1837) and Mason's of about the same date."

It seems proper to collect the evidence now existing on this point in order to show the desirability of the study of this nebula, and because, in case the indications which we there find of a decided proper motion should be confirmed, such results would be of importance.

Following I give in chronological order such extracts from published and unpublished observations of this nebula as bear on the points now under consideration, italicizing such portions as deserve particular attention.

OBSERVATIONS OF THE NEBULA.

This nebula was discovered by MESSIER June 5, 1764, but he gives no details concerning it.—*Hist. de l'Acad. R. des Sciences*, 1771, p. 443.

Observations of Sir William Herschel.

1784. July 12: "Three nebulæ faintly joined form a triangle. *In the middle is a double star.* Very faint and of great extent." —*Phil. Trans.*, 1786, p. 494.

1786. May 26: "A double star with extensive nebulosity of different intensity. *About the double star is a black opening*, resembling the nebula of *Orion* in miniature."—*Phil. Trans.*, 1789, p. 247.

1811. . . . . : "Three nebulæ seem to join faintly together forming a kind of triangle; the middle of which is less nebulous, or perhaps free from nebulosity; *in the middle of the triangle is a double star*, etc."—*Phil. Trans.*, 1811, p. 289.

236 Sweep. July 12, 1784: "Between 3 nebulæ (10, 11, 12, V class) is a double star."—*Mem. R. A. S.*, i, p. 167.

566 Sweep. May 26, 1786: "A double star within nebula IV, 41."—*Mem. R. A. S.*, i, p. 170.

Observations of Sir John Herschel.

1826 . . . . . : "In the nebula R. A. 17^h 52^m, N. P. D. 113° 1′ in *Sagittarius* * * * * the idea of an absorption by the double star in its middle is very forcibly suggested. This nebula is broken into three parts, and the three lines of division meet in *a vacancy, in the midst of which is situated the double star. This curious object has perhaps a proper motion.*"—*Mem. R. A. S.*, ii, p. 490.

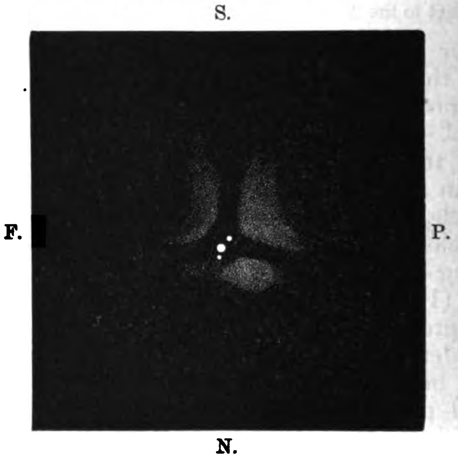

Fig. 1. Herschel, 1833.

1827 . . . . : "*A double star placed exactly in the central vacuity of a large irregular nebula*, which appears to have broken up into three portions by three rifts or cracks, extending from its center to its circumference, and *whose directions meet at the double star.*" —*Mem. R. A. S.*, iii, p. 63.

1833 . . . . : "*The double star* Sh. 379 *in the center of the trifid nebula*" . . . . [sweep 275].

"A careful drawing taken, but the nebula is not clear from twilight and clouds. (N. B. This drawing is unfortunately lost, and that engraved in fig. 80 is constructed from much less elaborate sketches, aided by memory.)" . . . . [Sweep 32.]

"Very large; trifid, three nebulæ with *a vacuity* in the midst, *in which is* centrally *situated the double star* Sh. 379."—*Phil. Trans.*, 1833, p. 460.

If we had nothing but the preceding evidence with regard to this nebula we should be justified in laying down the following proposition with regard to the situation of the triple star relative to the three nebulosities.

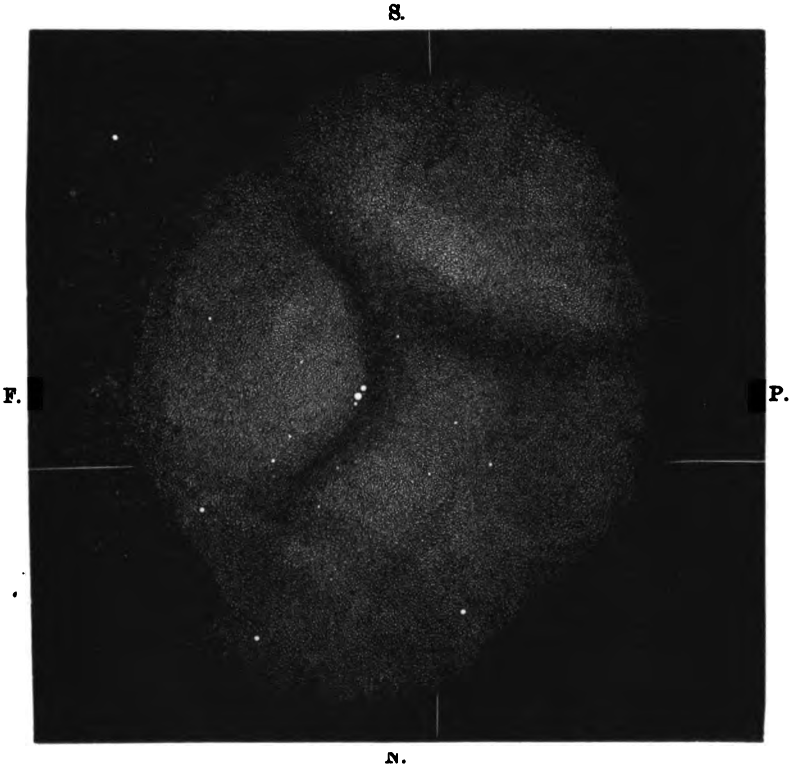

Fig 2. Mason and Smith, 1839.

𝒜. *From* 1784, *July* 12, *to* 1833, *this triple star was centrally situated between the three nebulosities.* The evidence is based upon two observations of Sir William Herschel and four observations of Sir John, and in the *Phil. Trans.* for 1811 Sir William again repeats his former statements.

Observations of MASON and SMITH.

1839. August 1: "*The double star is certainly not as figured in Phil. Trans.*, 1833, *but rather adhering to the* [*eastern*] *of the three divisions.*"

1839. August 9 . . : "*The triple star is certainly not central, but involved* * * *."—*Trans. Amer. Phil. Soc'y*, vol. vii, pp. 175–176.

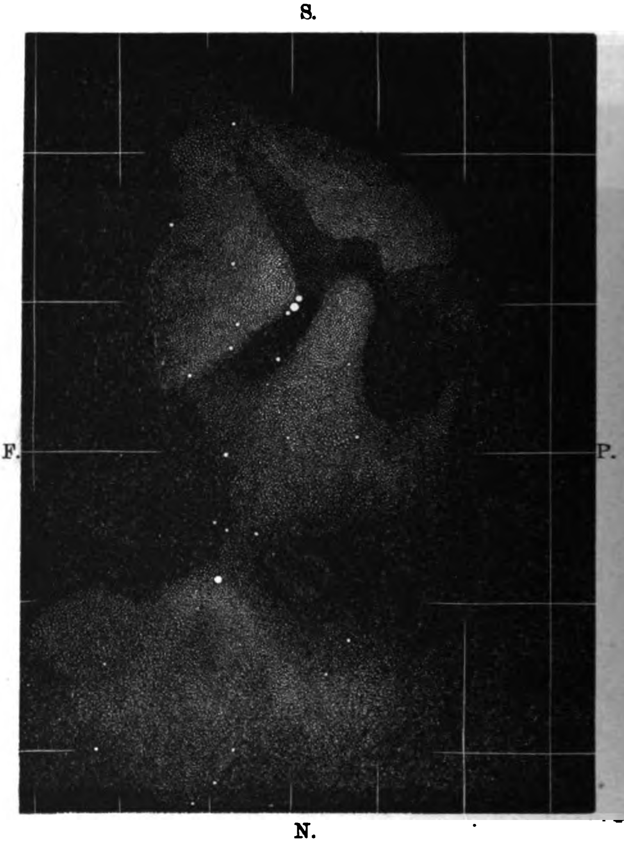

Fig. 3. HERSCHEL, 1834–8.

Observations of Sir JOHN HERSCHEL *at the Cape of Good Hope.*

1835. August . . . : "I have been rather unfortunate in my figures of this nebula. That given in my Northern Catalogue (our figure 1) is not to be taken as more than an attempt, and that a most rude and imperfect one, to show *the situation of the fine triple star in its center with respect to the nearer portions of the three principal surrounding nebulous masses.*

Herschel then speaks of the drawing of Mason (our figure 2) as follows:

"On comparing our figures they will be found to agree in every essential particular, allowing for the difference of light between reflectors of 12 and 18 inches aperture, with one rather remarkable exception, viz: in the form of the southern mass of the trifid nebula and the character of the three paths or avenues which lead up to the triple star. Mason represents these avenues as free from any abrupt change of direction, the northern and preceding of them branching out with and easy and graceful bifurcation from the southern; whereas my figure, whose correctness in this respect I cannot doubt, gives the preceding avenue a remarkably sudden and uncouth flexure, like a gnarled branch of an oak, just at its divergence from the other two."*—*Astron. Obser. Cape of Good Hope*, p. 10.

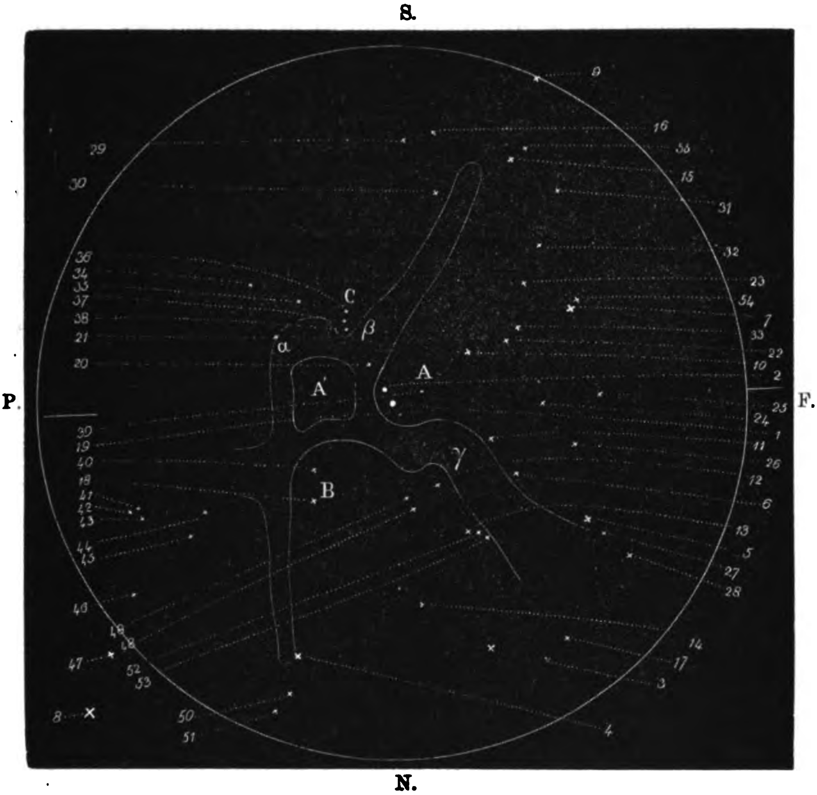

Fig. 4. Index-Map. (Lassell.)

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* In Mason's Memoir, Art. 46, p. 199, this appearance is recorded among the things "slightly suspected." His figure represents only "things certain," and probably Sir John Herschel referred only to the drawings in his comparisons.

The observations of Secchi[*] (1852–5) and of D'Arrest[†] (1866, June 2) throw no light on the position of the triple star relative to the nebula.

Later observations of the nebula are those of Lassell, Langley, Trouvelot and myself. (It has also been observed at Melbourne, but the Melbourne results are yet unpublished.)

Lassell's two figures are of high importance, having been made under the most favorable conditions at Malta with his 4-foot reflector, an instrument well suited to the purpose. They are published in the Memoirs of the Royal Astronomical Society, volumes xxxiii and xxxvi.

No verbal description of the nebula is given by Lassell, but the drawings are complete in themselves, and the evidence to be derived from them will be considered hereafter. The following micrometric observations were made by Lassell. In order to present the nomenclature of the stars the Index-Map (Lassell's) is given.

Table I.—LASSELL'S STAR-POSITIONS.[‡]

[The positions are referred to Star 1.]

Star 1 and Star —.	Observed.		Computed.	
	p.	*s.*	Δα.	Δδ.
3	25° 46′	270″·15	+117″·44	+243″·30
4	333 4	243·20	−110·16	+216·82
5	54 31	215·37	+175·38	+125·02
7	116 49	181·21	+161·72	− 81·75
8	311 24	391·68	−293·81	+259·03
10	121 30	90·39	+ 77·07	− 47·23
14	3 43	177·17	+ 11·49	+176·80
15	167 52	249·25	+ 52·39	−243·69
21	235 40	129·17	−106·67	− 72·85

Observations at Harvard College Observatory in 1866 *by* Prof. LANGLEY.

Through the courtesy of Prof. E. C. Pickering, Director of the Observatory of Harvard College, I have been enabled to extract from the observing books portions of observations made by Prof. S. P. Langley in 1866 with the 15-inch refractor of that institution. These are given immediately following, and in the proper place I have also given results derived from manuscript sketches by Prof. Langley. The measures of star coördinates are complete so far as they extend. I am informed by Prof. Langley that the sketches were, however, not regarded as completed, and therefore I shall only give those deductions from them which appear to have been regarded as certain at the time of observation. I desire especially to convey my thanks to Professors Langley and Pickering, who have allowed me to use these valuable materials.

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[*] Mem. dell' Oss. Coll. Romano, 1852–55, p. 89.

[†] Abhand. d. k. Säch. Gesell. d. Wissenschaften, vol. v, p. 343.

[‡] Memoirs Royal Astronomical Society, vol. xxxvi, p. 49.

Observations at the Harvard College Observatory.

1866. July 31.

Prof. Langley discovered the 4th star of Sh. 379 (D), which he estimated 13 mag., and which he described as "blue." It was independently seen by Prof. Winlock. Measures of coördinates made.

1866. August 2.

[The following remarks are copied *verbatim* from the original observing books, except that I have replaced the letters which are assigned to the stars by Prof. Langley, by Lassell's numbers, for the sake of uniformity. The explanations in square brackets are my own.]

"The nebula is brightest at 1. 6 and 11 are, if anything, outside of its confines. The prolongation [*north* of] 5 is very faint. It diminishes [in brightness] very slightly and uniformly toward 10 and 7? 1 is involved in faint nebulosity, which bridges the dark channel. The region about 1, 18, 12 is somewhat brighter than that in the triangle 7, 10, 11. 12 and 13 are a little within the nebulosity. The region [C] devoid of stars is perhaps the brightest part of the nebula, the dark channel [*south* of] 1 appearing relatively well defined. The whole heavens in the vicinity are (dubiously) nebulous."

1866. August 11.

Measures of coördinates of stars [omitted]. "Observed just *south* of 1, 10, 7, a faint, straight, narrow channel nearly filled up with nebulous matter. Was less confident to-night that the nebula surrounded the quadruple star, which seemed to be in the channel with blackness on each side, less in the *preceding* than in the *following* side."

1866. August 13.

Fifth component (E) of Sh. 379 discovered by Prof. Langley.

1866. September 10.

The entire region *south* of 1 [C] is judged, as before, to be the brightest part of the nebula, or nearly so. Cannot feel sure that there is *any* nebulosity about 1. The channel [*south* of] 1, 10, 7, is rather suspected than seen.

The drawing of M. Trouvelot was made with the aid of the Harvard College refractor (of 15 inches aperture) in 1874, and is published in the Annals of the Harvard College Observatory, vol. viii, plate 32. This plate is not here reproduced, as it has only recently been published, and is in the hands of astronomers. The evidence to be derived from it will be considered in its proper place. The following observations made by me with the 26-inch refractor of the U. S. Naval Observatory complete the materials at our disposal.

*Washington Observations in detail.**

I give the Washington observations almost literally from the observing books, in order that they may serve for future comparisons. Not infrequently a verbal statement can be made more definite and satisfactory than the presentation of the same evidence in a drawing.

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Washington Observations.

1874. August 12. Observers, S. W. Burnham and E. S. Holden: the subsequent observations are by the latter observer.

Sketch of stars made. 37 and 38 faint. Within 35″ of Sh. 379 are 4 stars, I, II (=Lassell's 20), III and IV. [These have been subsequently measured, see *Wash. Ast. Obs.* for 1874–5–7; of these I and IV were discovered by Prof. Langley at Harvard College Observatory.]

34 equal in brightness to 36. [The principal work of this night was the making of the star-chart.]

6 is certainly inside the nebulosity, but is close to its *preceding* edge. 11 is inside the nebulosity by ⅙ of the distance from 6 to 11, but the nebulosity is faint there; 12 and 13 both inside; 12 is nearer to the *following* edge of the nebula than 13. 52 is inside the nebulosity ? ? Clouds prevent further work.

1875. August 5.

6 is on the edge of A. 11 is on the edge of a brighter streak, but follows the *extreme* edge by about ⅙ the distance 6–11. From 11 to the point near the triple star [this refers to the point of the edge of the nebula A *north* of 1–2–19 and about the prolongation of the line 1–2; August, 1877] the edge is *faint* and tremulous. 12–13–52 all inside the nebulosity. In the line 13–52 the distance to the *following* edge (which is not always sharp) is about equal to the distance from 13 to 52. [This distance is to be measured from 52 toward the *following* side. 1877.]

A figure was made, from which the following notes are derived. The nebula is condensed around star 4. If a line be drawn joining 12 and 40, and if through 18 a line be drawn parallel to the former, this last line cuts the *preceding* edge of B at a distance from 18 equal to the distance 18–40. [This is quite different from Lassell's second figure, where the line described cuts the edge at a distance from 18 equal to about ⅓ or ½ of the distance 18–40.]

[The nebulosity near 44, 45, 41, 43 agrees with Lassell 1864 in the arrangement of the two degrees of brightness of the nebula.]

41, and 36, 37, 38 are all involved. 41 is involved by about the distance from 36 to 37 ?

20 is about the middle of the dark channel *β* [see index-map]. The angle of position of this channel *β* is 160° (1 measure).

β extends ⅜ of the distance from 20 to 9. [16 ?]

32 is immersed in nebulosity. The line 20–9 [16 ?] is nearly the axis of *β*.

[A second sketch of the bounding lines of the nebula made, which agrees more nearly with Lassell 1864 than the first one of this night, in the position of the nebulosity relative to the stars 18 and 40.]

The triple star Sh. 379 is really sextuple.

1877. July 2.

The following stars were identified and placed on the chart: 1, 2, 3, 4, 5, 6, 7, —, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, —, —, 44, 45, —, —, 48, 49, 50, 51, 52, —, 54, 55; leaving stars 8, 42, 43, 46, 47, 53 to be subsequently charted.

1877. July 6.

Measures of p, $\Delta\delta$, etc. See Table II. *Notes.*—48 has a little less $\Delta\delta$ than 18. 44 has a little greater $\Delta\delta$ than 18. The p of 1 and 12, 19°·2, is nearly that of 1 and 19. If anything the p of 1 and 19 is greater than that of 1 and 12.

1877. July 12.

Measures of p, $\Delta\alpha$, etc. See Table II. *Notes.*—The line 12–13 passes *west* of 1, and the nebulosity near 1 is still *west* of this line. Star 3 is *east* of the line 12–13 by about 1″ (est.). The line 1–18 bisects A (roughly speaking). 7 *precedes* 5 a little.

Along the line 14–20 there is nebulosity to the edge of γ, then darkness to the edge of A, then nebulosity to the edge of A again, then darkness in β. That is, the *preceding* edge of A is cut off by the line 14–20.

The nebulosity of A just *following* the line 14-20 is fainter for 3″-6″ (est.); but beyond this limit it is uniformly bright up to 1, 2, 19.

1877. July 13.

The line 14–20 is situated in regard to the nebulosity as in figure [omitted]; that is, the line 14–20 really passes through the nebula near 1, 2, 19, but through a fainter part. It is, however, *about* tangent to nebulosity of the same brightness as that near 1–2 on the following side. Eye-piece 175. The figure omitted shows following 1, 2, 19 a fainter band or dark channel, so that these three stars seem to be symmetrically situated in a brighter part of the nebula with fainter nebulosity again surrounding that, as if the nebulosity had condensed about these stars since Mason's drawing.

1877. July 16.

Measures of p and $\Delta\alpha$. See Table II. I suspect D to be variable. 11 very faint.

1877. July 25.

Measures of $\Delta\alpha$, $\Delta\delta$. See Table II. D and E seen. D is far brighter than any other of the small components of Sh. 379, of which only D and E are visible to-night. E is quite faint. E$<$20.

1877. July 26.

Moonlight. Placing the micrometer wire through 12–13 the wire runs *west* of 1, 2, 19, but is involved in fainter nebulosity near them. Half way from this wire to star 1 the nebulosity becomes bright, and so continues up to and beyond [*following*] 1.

With eye-pieces 400 and 600 A, the three stars 1, 2, 19 appear to be about symmetrically surrounded by an oval mass of nebulosity, separated from the rest of A by a fainter band following 1, 2, 19.

Line 14–20 is involved in A near 2, but only in fainter nebulosity.

Line 1–10 is involved *west* of 1 in brighter nebulosity by some seconds.

1877. July 30.

V. The line 3–35 is almost exactly parallel to the line 12–13, and intersects the nebulosity A near 1, 2, 19. This line is tangent very exactly to the *preceding* edge of the brighter nebula about these three stars.

Angle of position of β, passing through 20 and 16 (not 9), 162°·7 (1).

New dark channel between 1 and 10, as in sketch. It extends no further *east* than 10, and 10 and 11 are on or near its *following* borders. Its *preceding* border is 20″–30″ *following* 1, 2, 19. The seeing is poor, and this point should be reëxamined.

(A) The brightest part of the nebula is about the triple star. It is an oval mass nearly symmetrically disposed about the triple star. The triple star is, if anything, toward its *western* side.

(B) The next brightest nebulosity is near 36, but this is not much brighter than (C) or the brightest parts of (B) near 18.

(D) Stars 12–13 are both inside the nebulosity. [See Observations of 1875, Aug. 4; 1877, July 12, July 26.]

(E) Star 11 is on the very edge of a brighter portion, but *follows* the *extreme* edge by ⅛ the distance 6 to 11. [See Observations of 1875, Aug. 4.)

(F) Star 26 is within the brighter nebulosity, the boundary line of which runs (see sketch) [omitted] between 5 and 26, but much nearer 26 than 5; perhaps ⅛ of the distance 26 to 5.

(G) [Star 6 is certainly inside the nebulosity, about half way from the *preceding* edge of the fainter nebulosity to the *preceding* edge of the brighter.] See Observations of 1875, Aug. 4, Aug 5.

(H) Stars 5, 27 and 28 are on the *preceding* edge of the fainter parts of A. [But *preceding* 5, 7, 28 it is not totally black.]

(J) The triangle 40, 44, 21 has no nebulosity which is at all bright within it except A′.

(K) 21 is involved in C a few seconds, but it is close to its *north* edge. 35 is well involved. 36, 37, 38 are correct on the map.

1877. July 31.

$\Delta\delta$, 21 and 1, −65″·73 (3), −0″·09 refraction, $\Delta\delta = -65''{\cdot}82$. This is about the mean of the $\Delta\delta$'s of 38 and 37. Sketch of stars, etc., near 5, 17, 28.

The atmosphere on this night was more favorable than previously during the year, and the principal work was devoted to the examination of the apparent differences between Lassell's and Trouvelot's figures.

It appears that in an eye-piece having a small field (8′–9′), when 5, etc. is in the northern part of the field, and the eye endeavors to trace the *following* borders of the channel γ, that it is easy to gain the impression that 5 is on or near the *preceding* edge of A, and that *preceding* 5, 27, 28 the dark channel γ was prolonged toward the *north*. In this way the appearances of Herschel's, Mason's and Trouvelot's figures are reproduced.

Placing 5 in the center of the field, and thus avoiding the disturbing effect of the well marked border of the channel γ near

6 and 11, the appearances of Lassell's figure are most nearly represented. As before described, the nebulosity between 5 and 26 is mostly faint, but near 26 it becomes brighter, so that 26 is involved now more deeply in the brighter parts of (A) than is given by Lassell, and not so much as given by Trouvelot.

The nebulosity immediately about 4, 27, 28 is faint. The dark channel γ ceases to have well marked edges south of 5. The faint nebulosity about 5, however, does not seem to be connected (as in Lassell's figure) with (B).

August 3, 1877.

Night very clear. 1 and 14 $(\Delta\delta) = -211''\cdot37$ (2), $-0''\cdot30$ refraction, $\Delta\delta = -211''\cdot67$ (2). Lassell gives $-243''\cdot7$, and I presume there is an error in the numbering here.

Order of brightness of the principal stars.

1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 18, 20, 26, 21, 25. 39 and 24 are quite faint. Lassell's order of brightness is therefore maintained. Nebulosity was traced *north following* Sh. 379 a considerable way, about half a degree to a nebulous star 8^m, but I was hindered in this by clouds which finally covered the whole sky. The same hindrance occurred in the same way on the clear night of July 31. The connection of this nebula with neighboring ones deserves examination, as it is widely extended, but no opportunity offered during 1877 for this work.

With regard to the triple star: It was first seen double by Wm. Herschel, and triple by South and Herschel. Lassell with his four-foot reflector saw only three stars. Two stars, D and E, are to be seen on any clear night, D being about equal to star 20 in brightness and E tolerably faint. [I find among my notes several times a suspicion recorded that D is variable.] D and E were first seen by Prof. Langley with the Harvard College 15-inch refractor. They are both given by Trouvelot in his figure, together with a star *s.f.* 1, and very close to it. I have not seen this star in 1877. A = Lassell 1; B = 2; C = 3; F = 39.

The approximate positions of the various components are:

		p.		*s.*	
A and B	:	211°	:	10″·8	Sh. 379
A and C	:	22	:	6·5	
B and D	:	283	:	2·5	
A and F	:	107	:	19·5	
B and E	:	193	:	5·8	

This nomenclature includes Trouvelot's star s. f. 1. I have several times suspected the existence of a small star *n. p.* A. $p = 310° \pm$; $s = 6''$. For measures of the above stars, see the Washington Astronomical Observations and Burnham's Catalogue of Double Stars.

Prof. Eastman, U. S. N., has kindly undertaken to observe the triple star Sh. 379 on the Transit-Circle, in order to fix its position bsolutely.

The Washington observations of star positions are given in the table following. It will be noticed that in the column "Holden–Mason" the errors are usually within the limits set by Mason himself.

Table II.—SUMMARY OF WASHINGTON OBSERVATIONS OF STARS IN M. 20.

Date. 1877.	p. from 1.	Obs'd Δα from 1.	Diff. Refr.	Δα.	No. Obs.	Obs'd Δδ from 1.	Diff. Refr.	Δδ.	No. Obs.	Star No.	Holden—Mason.		Holden—Lassell.	
											Δα.	Δδ.	Δα.	Δδ.
July 6	55·9°(3)	″	″	″		+113″·71	0″·15	+113″·9	2		″	″	″	″
12	..	+166·56	+0·02	+166·6	3	..	..							
13	56·1 (2)	..				..	..			5	−10·0	+1·0	−8·1	−11·2
16	..	+167·25	+0·01	+167·3	2	..	..							
25	..	+167·92	+0·01	+167·9	1	+113·53	0·14	+113·7	2					
Means	56·0			+167.27				+113·80						
July 6	56·6 (3)	..	..			+67·35	0·08	+67·4	2					
12	..	+101·22	+0·01	+101·2	2	..	..			6	+5·4	+7·1	..	..
13	56·8 (2)	..	..			+66·86	0·09	+67·0	2					
16	..	+101·41	+0·01	+101·4	2	..	..							
Means	56·7			+101·30				+67·20						
July 6	65·3 (3)	..	..			+39·20	0·05	+39·3	2					
12	..	+83·78	+0·01	+83·8	3	..	..			11	+4·0	+0·1	..	..
13	65·5 (2)	..	..			+38·53	0·05	+38·6	2					
16	..	+83·66	0·00	+83·7	2	..	..							
Means	65·4			+83·75				+38·95						
July 6	28·6 (3)	..	..			+119·67	0·15	+119·8	2					
12	..	+51·58	+0·02	+51·6	2	..	..			18	+1·8	+9·7	..	..
13	28·3 (2)	..	..			..	..							
16	..	+51·66	+0·01	+51·7	3	..	..							
25	..	+51·52	+0·02	+51·5	1	+119·13	0·15	+119·3	4					
Means	28·5			+51·60				+119·55						

Table II—continued.

Date. 1877.	p. from 1.	Obs'd Δα from 1.	Diff. Refr.	Δα.	No. Obs.	Obs'd Δδ from 1.	Diff. Refr.	Δδ.	No. Obs.	Star No.	Holden—Mason. Δα.	Holden—Mason. Δδ.	Holden—Lassell. Δα.	Holden—Lassell. Δδ.
July 6	19°·2(3)	″	″	″		+75″·41	0″·09	+75″·5	2		″	″	″	″
12	--	+26·00	+0·01	+26·0	2	--	--							
13	19·5 (2)	--	--			+75·18	0·10	+76·3	2	12	+0·2	+4·0	--	--
25	--	+26·00	+0·01	+26·0	2	--	--							
Means	19·4			+26·00				+75·90						
July 12	--	+11·84	+0·03	+11·9	2	--	--			14	--	--	+0·9	−2·4
13	4·1 (2)	--	--			--	--							
25	--	+12·86	+0·06	+12·9	3	+174·19	0·23	+174·4	2					
Means	4·1			+12·40				+174·40						
July 6	213·0 (3)	--	--			−33·1::	0·04	−33·1::	3					
12	--	−22·9	−0·00	−22·9	3	--	--			20	--	--	--	--
13	--	--	--			−34·46	0·04	−34·5	2					
25	--	--	--			−33·43	0·04	−33·5	3					
Means	213·0			−22·90				−33·7						
July 6	--	--	--			+88·34	0·11	+88·45	2	18	+1·0	+7·6	--	--
12	--	−69·18	+0·01	−69·2	1	--	--							
13	321·9 (2)													
Means	321·9			−69·20				+88·45						
July 6	334·4 (3)	--	--			+212·39	0·25	+212·64		4	--	−3·9	--	−2·2

Besides the above measures, which are all referred to Star 1, the following angles of position have been measured:

July 12: Stars 12 and 13, $p =$ 30°·5 (3) } 1875, Aug. 5: Angle of position of β : 160°·0 (1)
July 13: Stars 14 and 20, $p =$ 189°·7 (1) } 1877, July 30: Angle of position of β : 162°·7 (1)

It should be noted that the measures on which the above positions depend have all been made under very unfavorable circumstances.

Table III.—STAR POSITIONS ACCORDING TO HERSCHEL, MASON, LASSELL, LANGLEY AND HOLDEN.

Star's Number.			Magnitude.		Herschel.		Mason.†		Lassell.		Langley.		Holden.	
Lass.	Hersc.	Mason.	Hersc.	Mason.	Δa.	Δδ.*	Δa.	Δδ.	Δa.	Δδ.	Δa.	Δδ.	Δa.	Δδ.
8									−293″·8	+259″·0				
4	1	2	12	11·12	−120″·0	+211″·3	−111″·8	+216″·5	−110·2	+216·8	−103″·1	+210″·8	..	+212″·6
21									−106·7	−72·9			..	−65·8
--	2		15		−103·5	+93·6								
40 ?		3		16			−98·7	+28·9						
21 ??		4		16			+83·7	−39·1						
18		5		15			−70·2	+80·9					−69″·2	+88·5
35	5		15		−61·5	−72·1								
36 37 38	?	6		16			−41·7	−63·1						
20													−22·9	−33·7
14	7 ?		15		−4·5	+199·5			+11·5	+176·8	+11·0	+176·6	+12·4	+174·4
12	10	11	13	15	+27·0	+86·5	+25·8	+71·9			+26·1	+74·6	+26·0	+75·9
15 ? 16 ?		12		15			+33·3	−187·1						
13	11	13	13	15	+48·5	−128·6	+49·8	+109·9			+50·5	+118·2	+51·6	+119·6
15‡									+52·4	−243·7				−211·7
10		16		14			+66·3	−34·1	+77·1	−47·2	+68·5	−37·8		
11		17		14·15			+79·8	+38·9			+84·1	+37·9	+63·8	+39·0
11 ?	13		13		+99·0	+27·6								
6	15	19	11	12·13	+106·5	+69·7	+95·9	+60·0			+100·9	+68·2	+101·3	+67·2
22 ? 33 ?	17		12		+114·0	−67·3								
3	18	21	11	11·12	+114·0	+240·4	+118·7	+239·7	+117·3	+243·3	+119·1	+237·0		
7		24		12·13			+172·1	−70·4	+161.7	−81·8	+159·9	−76·1		
5	24	25	11	12	+178·5	+108·0	+177·3	+112·8	+175·4	+125·0	+169·2	+114·8	+167·3	+118·8

* The sign of Δδ as given by Herschel in C. G. H. Obs. has here been changed. ‡ There is some error in the numbering of 15.

† Mason estimates the mean errors of his star positions as ± 0^s·399 and ± 6″·37.—*Op. cit.*, p. 192.

Position of the mass A relative to the triple star.

It will be convenient to examine the various drawings with regard to special points, and to lay down a series of propositions (so to say) from each figure which can afterwards be compared among themselves. The situation of the triple star with respect to the adjacent nebulosity being of importance, I give in what immediately follows five statements derived from each drawing, which go to show the position of the nebulosity *A* near the triple star at the epoch of the drawing.

The statements derived from each drawing are here placed together, in order to facilitate the comparison between the original engravings and the propositions I have derived from them. In the actual examination of the drawings, each one was studied separately, and all the evidence to be derived from it recorded, and the various data were subsequently collated. In this way a tolerably independent judgment can be formed.

In Sir John Herschel's Cape of Good Hope figure we find:

I. Stars 1–2–19 are on the very edge of A.
II. The line 12–13 does not intersect A.
III. The star 20 is not laid down.
IV. The line 1–10 is not involved *preceding* 1.
V. The star 35 is not laid down on the drawing, although given in the Catalogue.

In general the agreement with Mason's drawing is good for the mass *A* near 1, 2, 19. In the figure given by Mason and Smith:

I. Stars 1–2–19 immersed in A.
II. The line 12–13 does not intersect A, but passes *west* of it by about 15″.
III. The star 20 is not laid down, as it was too faint for Mason's telescope.
IV. The line 1–10 *preceding* 1 is involved in A by a little over 14″.
V. 35 is not laid down in his drawing.

These measures are not made on the engraving representing the nebula as it appears to the eye, but on the contour map (Mason's Plate II). The two plates agree however, but the second is more useful for a purpose like the present one, as it was seen by Mason that it would be.

During his residence at Malta in 1862–4, Lassell presented to the Royal Astronomical Society a figure of this nebula drawn under his direction, which is referred to in the *Memoirs* of that society, vol. xxxiii, p. 121, and figured in Plate I of that work. This figure need not be here given, as essentially the same observations are represented in Lassell's second figure in the vol. xxxvi of the same series (p. 48 and fig. 32, Plate VIII), which we give below. The first of these figures we may, however, briefly describe in some important points, using Lassell's nomenclature for the stars, as given in the last cited work and Mason's nomenclature for the nebulosity, as in our Index-map.

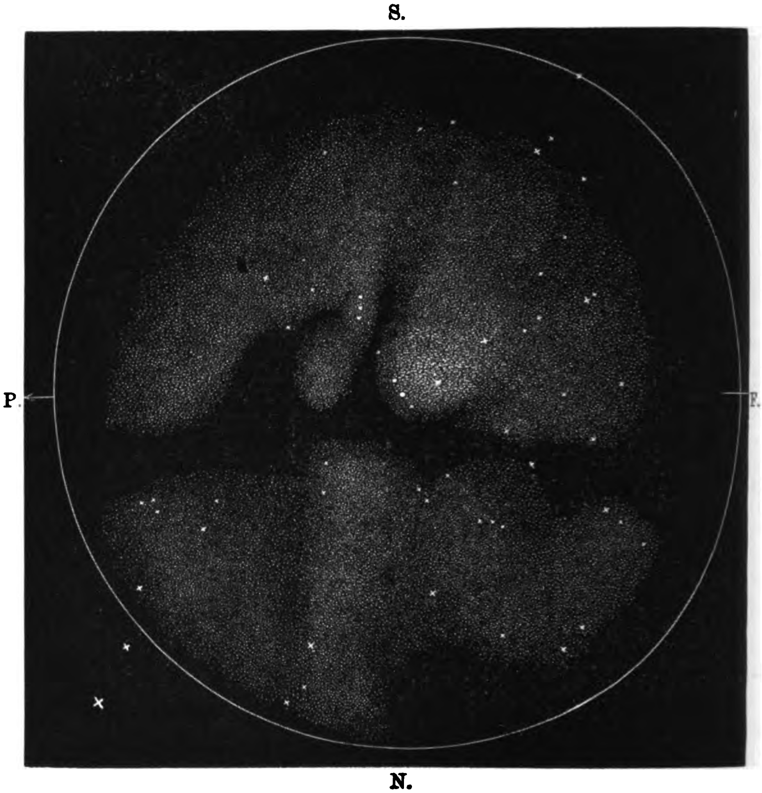

Fig. 5. Lassell, 1862.

Lassell's first figure.

I. Stars 1, 2, 19 are immersed in the nebula.

II. The line of stars 12–13 prolonged passes through the nebulosity of A. If we draw the shortest line from star 2 to the preceding edge of *A* this line is cut by the line 12–13, prolonged at about one-third its length from its preceding end, and this line is involved in the nebula near 1, 2, 19, for about 30′ of its length.

III. The line from 14 to 20 cuts the line from 2 at about its middle point, and is involved in the nebula near 1, 2, 19 for about 30′ of its length.

IV. The line 10–1 is involved in nebulosity *preceding* 1 by about 16″·6.

V. The line 35–3 is nearly tangent to the *preceding* edge of the nebula A.

Lassell's second figure.

This figure is the result of repeated observations and is to be considered as more trustworthy than the former.

I. Stars 1, 2, 19 are immersed in *A*.

II. The line of stars 12–13 prolonged passes through the nebulosity A *preceding* 1, and is involved in the nebula *A* for about 25″ of its length.

III. The line 14–20 is involved in *A* for about 17″. It is to be noted here that all of A which *precedes* the line 1, 2, 19 is in this drawing considerably fainter than that just on the border of which 1, 2, 19 are situated.

This is not so given in the earlier figure, but probably this second figure represents more exactly the careful observations of Lassell himself. Returning to the second figure we find:

IV. The line 10–1 is involved in nebulosity *preceding* 1 by about 16″·6.

V. The line 35–3 is approximately tangent to the *preceding* shore of A.

From the Harvard College observations by Professor Langley and from sketches accompanying them the following conclusions may be drawn. As remarked by Prof. Langley these conclusions are not of the same weight as the micrometric observations.

I. Stars 1, 2, 19 are *not* immersed in A, but are in the dark channel which, however, is filled with faint nebulosity.

II. The line 12–13 prolonged is not involved in the nebulosity A.

III. Stars 14–20 not laid down.

IV. Line 1–10 *not* involved preceding 1.

V. 35 not laid down.

In the drawing made by M. Trouvelot at Harvard College Observatory*—

I. Stars 1, 2, 19 are immersed in *A*.

II. The line 12–13 does not intersect A, but passes *west* of it by many seconds.

III. The line 14–20 is not involved in A at all.

IV. The 1–10 preceding 1 is involved in A.

V. The star 35 is not laid down.

From the Washington observations it appears that—

I. 1, 2, 19 are immersed in *A*.

II. The line 12–13 prolonged passes through *A*. Half way from this line to the line 1, 2, 19 the nebulosity becomes brighter, and so continues up to 1. That is, the line 12–13 is involved in the fainter nebulosity.

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* Annals Harvard College Observatory, vol. viii, plate 32. This figure is not copied, as it is but lately published and is in the hands of astronomers.

III. The line 14–20 cuts off the *preceding* borders of *A*, but is involved only in fainter nebulosity. It is, however, about tangent to the brighter nebula about 1, 2, 19.

IV. The line 10–1 prolonged is involved in A *preceding* 1.

V. The line 35–3 is almost exactly parallel to the line 12–13 [$p=30°\cdot5$], and intersects A near the triple star. This line is tangent very exactly to the preceding edge of the brighter nebulosity about these three stars.

We may make the following summary of the evidence with regard to the position of the triple star relative to the nebulosity.

I. The stars 1, 2, 19 are situated in Herschel's (1837) figure on the very edge of *A*, but in Mason's figure and in his notes, "Things Certain," he places these stars *within* the nebula, and probably a consideration of the two memoirs will result in the conclusion that here Mason was right and that we must suppose the triple star to have been involved in 1837–9. It is all the more proper to come to this conclusion as Herschel does not expressly say that the stars are on the edge, his evidence, at the best, being negative on this point. We therefore may assume with confidence that Mason's figure and memoir give the relative position of these stars and the nebula correctly for 1837–9. It is to be noted here that this position is utterly different from the one derived from the evidence of the earlier observations.

In the absence of *satisfactory* micrometric measures (which indeed are almost impossible to make on this point even with faintly illuminated wires), it may be said that Lassell's (2 figures), Trouvelot's and my own observations agree in this respect with Mason's, allowing for difference of telescopes. We may therefore say with certainty that—

I. *From* 1839 *to* 1877 *the triple star was not centrally situated between the three nebulosities, but was involved in A.* The evidence to be derived from the earlier observations at Harvard College is alone opposed to this conclusion, and these may perhaps be explained by supposing the brightness of the stars 1, 2, 19 to have overpowered that of the nebula near them. At the same time it must be noted that in several respects these observations vary from other later ones, and it is to be remembered that the evidence is here mostly derived from verbal and definite descriptions, and therefore are of greater weight than if deduced only from drawings.

II. The line 12–13, according to Herschel, does not intersect *A*; Mason—does not intersect *A*; Lassell (1)—does intersect *A*; Lassell (2)—does intersect *A*; Langley—does not intersect *A*; Trouvelot—does not intersect *A*; Holden—does intersect *A*.

III. The line 14–20, according to Herschel, cannot be traced; Mason—cannot be traced; Lassell (1)—is involved in *A*; Lassell (2)—is involved in *A*; Langley—is not involved in *A*; Trouvelot—is not involved in *A*; Holden—is involved in *A*.

IV. The line 10–1; the evidence under this head corroborates that under I, except in the case of Harvard College, 1866.

V. The line 35–3: Herschel, star 35 not laid down; Mason, star 35 not laid down; Lassell (1), stars 35–3 about tangent to *A*; Lassell (2), stars 35–3 about tangent to *A*; Langley, star 35 not laid down; Trouvelot, star 35 not laid down; Holden, line 35–3 intersects the fainter nebulosity A, but is about tangent to the brighter part of A near the triple star.

In these points I–V, it appears that there are few discrepancies that the difference in telescopes will not explain, and inference B is confirmed.

General notes on the brighter portions of the Nebula.

The *brighter portions* only are considered, in order to avoid as much as possible the discrepancies arising from differences of instrumental power.

In this examination again it will be convenient to derive a series of propositions from each drawing in succession, which can afterwards be compared.

The following analysis may be made of the figure of Herschel (1837).

A. The brightest nebulosity is that *following* 1–2–19, that called B, and that called C. The bounding line of C is strangely different in Herschel and Mason's figures, as remarked by the former. Mason refers in his notes to the outline as given by Herschel.

B. } To understand the distribution of the fainter nebulosity,
C. } a reference must be made to the drawing.

D. Star 12 is on the very edge of the *following* side of B. It might even be supposed to have been intended to be laid down in the channel γ. 13 is immersed, but not much.

E. Star 11 is immersed in *A*.

G. Star 6 in immersed in *A*.

H. Star 5 is on the *preceding* side of *A*.

J. The triangle defined by stars 40, 44, 21 [these stars not being laid down by Herschel makes this inference somewhat doubtful] would be largely free from nebulosity of any considerable degree of brightness.

K. Although the stars of Mason 6 and 4 are not laid down, yet the general agreement of the northern boundary of C near 1, 2, 19 as laid down by Mason and Herschel respectively, is very good.

L. . . . . From the engraving I find that about 7^s *preceding* 1 the $\Delta\delta$ of the southern well defined and bright edge of B is $38''$; the width of the channel α is $85''$, and therefore the $\Delta\delta$ of the north edge of C near where star 21 would be, is $123''$.

With reference to the distribution of the nebulosity in Mason's figure we may lay down the following propositions:

A. The brightest nebulosity is that immediately following 1, 2, 19; that surrounding his star 5 [= Lassell No. 18], and that near Mason 6.

B. }. The fainter orders of nebulosity are pretty uniformly and
C. { symmetrically disposed about these three brighter centers. This is better understood from the figure than from a description.

D. Stars 12 and 13 are immersed in nebulosity.

E. Star 11 *follows* the edge of the nebula a considerable distance.

G. Star 6 is somewhat immersed in *A*.

H. Star 5 is on the *preceding* edge of *A*.

J. The triangle whose vertices would be in the positions of Lassell's stars 40, 44, 21 is completely filled with tolerably bright nebulosity.

K. The stars Mason 6 and 4 are both immersed in nebulosity, 6 in very faint nebulosity, 4 in a brighter part. The channel α is south of these. The $\Delta\delta$ of 6 and 4 is according to Mason $-63''$ and $-39''$.

L. The $\Delta\delta$ of the south edge of B is about the mean of the $\Delta\delta$'s of stars [Mason] 4 and 6, that is, about $51''$. About 7^s preceding 1, the $\Delta\delta$ of the extreme *northern* limit of C is about $187''$.

In regard to the distribution of the nebulosity in Lassell's figure we may remark:

A. The brightest nebulosity is immediately about and *following* 1, 2, 19.

B. The next order of bright nebula is about stars 35, 36, 37; i. e., just *south* of 1, 2, 19 in the line 1–20.

C. The third order of bright nebulosity is between stars 12, 48, 40 and stars 40, 18.

D. Stars 12, 13, 52 and 53 are immersed in nebulosity.

E. Star 11 is just on the edge of *A*.

F. Star 26 is just on the edge of *A*.

G. Star 6 is nearly in the middle of the dark channel γ.

H. Stars 5, 27, 28 are immersed in the *following* border of B.

J. The triangle 40, 44, 21 is free of nebula.

K. The stars 21, 36, 35 are immersed in C *south* of the channel α.

L. The *southern* limit of B instead of being as in Herschel and Mason's figures over $100''$ *south* of 1, is over $60''$ *north* of it. The $\Delta\delta$ of the *north* shore of C is (roughly) about $-70''$.

Lassell's first figure confirms the above propositions in general. The only changes necessary to introduce are with regard to—

D. 12, 13, 52 on the edge or *following* the edge of B.

F. Star 26 outside of *A*.

H. 5, 27, 28 *follow* the *east* edge of B.

J. The triangle has a patch of faint nebulosity in it (*A'*).

From the MS. observations and drawings of Professor Langley the following conclusions may be drawn:

A. "The brightest nebulosity is about 1" (August 2d). "The region *south* of 1 is judged to be the brightest" (Sept. 10).

B. }
C. } See the observations in detail.

D. Stars 12, 13 are immersed.

E. Star 11 is, if anything, outside of *A*.

F. Star 26 not laid down.

G. Star 6 is, if anything, outside of *A*.

H. Star 5 is near the *preceding* edge of *A*, but immersed.

J. 40, 44, 21 not laid down.

K. Stars 36? 35? are immersed in C *south* of the channel α.

L. No measures possible on the sketches, but it in general agrees with Trouvelot.

From the drawing of M. Trouvelot, which gives the general effect of the nebula to the eye better than any other, we deduce what follows:

A. The brightest part of the nebula is in *A south* following 1, 2, 19.

B. Next in order of brightness is the nebulosity about star 40.

C. The northern borders of C are next in order of brightness.

D. Stars 12 and 13 are immersed in B.

E. Star 11 *follows* the extreme edge of *A* a little (see his outline-map of stars in Annals H. C. Obs., vol. viii).

F. Star 26 is uniformly surrounded by tolerably light nebulosity.

G. Star 6 is within the *preceding* edge of *A* (outline-map).

H. Star 5 is within A (outline-map).

J. The triangle 40, 44, 21 contains a considerable amount of pretty bright nebulosity.

K. Star 21 is on the *northern* border of C. Stars 35 and 36 are not laid down.

The results A, B, ... K, for the Washington observations are laid down in the detailed transcription of those observations (1877, July 30) and need not be repeated here. As to L, we may say that the $\Delta\delta$ of the *north* shore of C, 7^s *preceding* 1 is about $-65''$.

We may summarize the foregoing results as follows: First as to the distribution of the brightest portions (A, B, C). In all of the drawings the nebulosity closely *following* the triple star is of the first order of brightness, while in the Washington observations between 1 and 10 a darker band exists. I am disposed to believe that this band has simply been overlooked, although the two careful figures of Lassell might be supposed to militate against this view. In these no dark band closely *following* 1, exists.

It is possible that the brightness of the stars 1, 2, 19 produces by contrast part of the effect noted.

D. In spite of minor differences the general agreement as to the situation of stars 12 and 13 is good. Lassell's first drawing if not corrected by his second would be difficult to explain in this respect.

E. According to Herschel: star 11 is immersed in A; Mason, star 11 is deeply immersed in A; Lassell, star 11 is just on the edge of A; Langley, star 11 is not immersed in *A*; Trouvelot, star 11 is very slightly immersed in A; Holden, star 11 is on the very edge of the brightest portion, but *follows* the extreme edge a little.

Here Herschel and Mason agree with each other, but differ from the later authorities.

F. According to Lassell: star 26 is just on the edge of *A*; that is, the space between 26 and 5 is totally black. In his first figure 26 is completely free from A, *preceding* the edge; Trouvelot, star 26 surrounded on all sides by uniform nebulosity; Holden, star 26 is within the *brighter* nebulosity of A, whose boundary line runs between 5 and 26 at a distance from 26 equal to about $\frac{1}{5}$ the distance of these stars.

The evidence under this head should be considered in connection with that under H, which is for comparison next given.

H. According to Herschel: star 5 is on the *preceding* edge of *A*; Mason, star 5 is on the *preceding* edge of *A*; Lassell, stars 5, 27, 28 are immersed in the *following* border of B. In Lassell's first figure these three stars are entirely free from nebulosity and *follow* the *east* edge of B; Langley, star 5 is within *A*; Trouvelot, star 5 is within A; Holden, stars 5, 27, 28 are on the *preceding* edge of a fainter strip of nebulosity which begins (at 6) to border A and continues northward beyond 28. The *preceding* edge of the brightest parts of A is very close to 11, a little *east* of 6, about $\frac{1}{5}$ [26—5] preceding 26, etc. If one follows the edge of the nebula A northward from 1 to 5 at the telescope and without previous familiarity with the actual contours, 5 will certainly at the first glance appear to be on or near the extreme edge of A. A little examination shows that the description given in the Washington observations is correct (in 1877), but I have not been able to see how the exact effect given in Lassell's two drawings (by two different observers, be it remembered, at different times) can be produced. At the same time, I have no doubt that the appearance given by Lassell was a true one for 1862–4, and a slight change in the intensity of the nebulosity between 26 and 5 would reduce the nebula as described in the Washington observations to the appearance as given by Lassell. A change in the reverse direction is needed to reconcile the appearances given by Lassell and Mason

While, therefore, no definite conclusion can be reached (as Lassell's drawings of nebulæ in general are of the highest value, being among the very best extant, and as, therefore, we must not only accept them as evidence, but as very positive and conclusive evidence), it is possible that some slight changes of brilliancy (apparently none of situation) may have occurred in the region 28, 17, 13, 26 during the past forty years.

Resuming the previous order:

G. According to Herschel: star 6 is immersed in A; Mason, star 6 is immersed in A, but is very near the edge; Lassell, star 5 is nearly in the middle of the dark channel γ. Both figures confirm this; Langley, star 6 is not immersed in A; Trouvelot, star 6 is within the extreme boundary of A, but close to edge of the brightest part; Holden, star 6 is about midway between the *preceding* edges of the faint nebulosity bordering A, and the edge of the brighter parts of A.

The evidence above seems to me to indicate some decided changes in the brightness [and position] of the edge of A near 6. The first two and the last two authorities agree, and both differ from Lassell and from Langley. Accepting Lassell's authority, some change has here taken place, and it appears that it is connected with the suspected changes *F* and *H*. Langley's observations are not widely different from the later ones, but seem to confirm Lassell's.

J. The triangle defined by 40, 44, 21 is, according to Herschel: free from any marked nebulosity; Mason, completely filled with tolerably bright nebulosity; Lassell, free from nebula (2d figure), free from nebula except *A'* (1st figure); Trouvelot, contains a considerable amount of pretty bright nebulosity; Holden, contains no nebulosity at all bright except *A'*.

Here the various accounts do not agree. Positive evidence is more to be considered than negative, and this triangle in 1837 was probably filled with nebula considerably bright. It is not so now. Trouvelot's figure really agrees with Lassell's and my own, if we correct a little distortion of his figure near this part.

K and L. The point to be settled is, has the channel α remained unchanged? From Herschel's figure we derive the following:

The apex of A' (which in his figure is continuous with B, and is indeed about the brightest portion of the nebula, quite different from now) is about 38 seconds of arc *south* of 1. The $\Delta\alpha$ of this apex is (approximately) -7^s. The width of the channel α at this point is 85 seconds. Hence the *north* shore of C in the R.A. -7^s (from 1) is in $\Delta\delta$ $-123°$.

From Mason's figures (assisted here by the measured positions of stars 4 and 6 of his list) we find the *south* shore of B in $\Delta\delta$ −51″; and the $\Delta\delta$ of the *extreme* northern limit of C 187″. An acquaintance with Mason's memoir is necessary in order to understand the great dependence to be placed on his work.

In Lassell's figure we find star 21 nearly on the *northern* limit of C, and hence in the (measured) $\Delta\delta$ −73″·9. In Lassell's figures the part *A′* is completely detached from B by a wide, black opening. In Trouvelot's drawing A′ is continuous with B, and in my own sketches A′ is indeed separated from B, but by a narrow and not very obvious channel. In respect to the *southern* parts of B we have then the following successive results.

From my own observations the contour of the *north* shore of C near stars 21, 36, 37, 38 is similar to Lassell's, and the $\Delta\delta$ of 21 which gives the $\Delta\delta$ of this north shore is −65″. Collecting the various authorities—

Herschel: $\Delta\delta$ of north shore of C = −123″.
Mason: $\Delta\delta$ of north shore of C = −187″. (measured.)

Lassell: $\Delta\delta$ of north shore of C = − 73″. "
Trouvelot: $\Delta\delta$ of north shore of C = − 60″.
Holden: $\Delta\delta$ of north shore of C = − 65″. "

The last three authorities may be said to agree: the first two agree in placing the *north* shore of C 1′ or more further *south*. The amount by which it is further to the *south* is probably best given by Mason's figures, for reasons already cited here, and spoken of in general by Herschel himself (*loc. cit.*, p. 11, foot note.)

If there had been no stars (Mason's 4 and 6) near the area in question, this conclusion would not be so definite as it now appears to be. In fact, the positions of these stars were fixed and then the nebulosity was drawn about them. It is certainly not about these stars now.

The space A′ about 7^s *preceding* 1 and between the parallels of $\Delta\delta = 0''$ and $\Delta\delta = -38''$ is, according to Herschel, about the brightest portion of the nebula and continuous with the rest of B; Mason, nearly equal to the brightest parts of the nebula, and continuous with the rest of B; Lassell, totally black; Trouvelot, pretty bright, and part of B; Holden, bright, but separated from B by a narrow channel.

In this respect, regarding all the drawings as of equal or nearly equal accuracy, there has undoubtedly been a decided change.

RECAPITULATION OF THE PRECEDING RESULTS.

We may now collect such of the preceding results as we have found important. First it has appeared—

𝔄. *From* 1784, *July* 12 *to* 1833, *the triple star was centrally situated between the three nebulosities.*

Again,

𝔅. *From* 1839 *to* 1877 *the triple star was not centrally situated between the three nebulosities, but involved in A.*

It has previously been seen that each of these propositions rests on a firm basis. Granted that 𝔄 and 𝔅 are correct, I know of but three ways to reconcile the opposing facts:

a. The triple star has a large proper motion.
b. The nebula A has a large proper motion.
c. The nebula A is subject to decided changes of brilliancy.

The first point will be settled by meridian observations now in progress. The relative positions of 1 and the various stars of the group seem to have been unchanged since Mason. If, as is probable, the proper motion of the triple star is small, there remain the two alternatives *b* and *c* to choose between.

We have seen that the evidence with regard to the position of the nebulosity A relative to the star 6, indicates changes in the brightness and position of this part of A. This appears to be connected with changes much less certain near star 5, etc. It has also appeared that in 1839 the nebula B was about the stars Mason 4 and 6. This is confirmed by Herschel's earlier figure, and is totally and entirely different from present appearances. This conclusion is also confirmed by the marked and glaring differences in the description of the region *A′*.

Each of the above inferences rests on undoubted authority, and only cases are included here in which no doubtful points have arisen. It therefore appears to me to be a just conclusion that—

The evidence as recorded *with regard to this nebula indicates marked changes of position or brilliancy, or both, during the period* 1784–1877. The conjecture of Sir John Herschel, "perhaps this singular object has a proper motion," will be recalled in this connection.

I have, in my own mind, no doubt but that the *evidence as recorded*, if thoroughly examined by any competent person will lead to the same conclusion. The examination of many drawings of nebulæ has, however, led me in common with others, to the conclusion that too great care cannot be exercised in interpreting drawings of this class. Drawings and observations made from one point of view have to be interpreted from quite another and a different one, and misreadings and misinterpretations are likely to occur. It is for this reason that I have given my own observations in detail, so that they may be repeated step by step at any subsequent time; and for the same reason, I have given in full the analysis of the separate drawings so that each point can be verified or rejected by any one who has the original drawings before him.

This method of examining each drawing, deducing from it all the evidence on all the points in question, and then collating the various data under each separate head, not only enables the whole work to be quickly verified, but it enables the person collating the evidence to form the final conclusions with little or no danger of bias or prejudice. The principal question is as to the goodness of the evidence itself. It may be worth while in this case to examine the evidence and to see *what must be rejected* in order to suppose that this nebula has remained *unchanged* from 1784 to 1877. First then, Sir William Herschel speaks of the triple star as being "in the middle" of the three nebulosities on several occasions. Sir John Herschel is explicit as to its being "in the midst" and "exactly in the center" of the "central vacuity.". Inference 𝔄 rests on these statements, which could not have been made more definite by Sir John Herschel and which are strongly corroborated by Sir William Herschel. 𝔄 is undoubtedly correct. Hence I believe that the previous inferences regarding the relative motion of the triple star and the nebula should stand, and are correct.

The further conclusions as to change, as I have given them, could have been deduced from the drawings of Mason and Lassell alone, combined with my own observations. The observations of Langley, Trouvelot and Herschel simply corroborate the others in general but are not *essential.* The internal evidence of Mason's paper shows that in spite of his inexperience he was fully aware of the nature of the problem to be solved, and his results are entirely trustworthy. In every point noted as "certain," (and only such points are recorded in the drawing,) his work was verified by his coadjutor, Mr. H. L. Smith. Lassell's drawings are well known, and his series is among the best we have. In this case fortunately we have *two* separate and independent drawings by different hands which support each other. There can be no doubt of their standard character. In regard to my own observations, I am satisfied that they are, in the main and on essential points, correct. The season of 1877 was very unfavorable and the star positions could be improved, but I do not think any error of moment remains. It therefore seems to me that the evidence remaining to be examined is such that it ought not to be rejected, and that the previous conclusions should stand.

ART. XLIX.—*The Northern Part of the Connecticut Valley in the Champlain and Terrace Periods;* by WARREN UPHAM.

A CAREFUL exploration of the stratified drift bordering Connecticut River on both sides, from its source to the north line of Massachusetts, has been made for the geological survey of New Hampshire. Much of the present essay, which is based on this work, will be published, with additional details, in the third volume of the report on that survey.

At the end of the *Glacial period*, this valley, like every other prominent valley in New England, received thick beds of gravel, sand and clay, or fine silt. These were deposited during the *Champlain period*, which embraces the time occupied by the final melting of the great ice-sheet. During the *Recent or Terrace period*, the work of deposition has not been equal to that of erosion, and the rivers have excavated deep and wide channels in the Champlain deposits.* This erosion along Connecticut River has been 100 to 200 feet in depth, and a quarter of a mile to one mile or more in width.

The river-lands here to be considered include the interval, or present flood-plain, frequently known as meadow along the Connecticut, and called bottom-land in the western States; and terraces, which rise in steps on each side of the river, the highest often forming extensive plains. This highest deposit is found to have about the same height upon both sides, and to extend continuously, with nearly the same slope as that of the river, along the whole valley, being broken only by the entrance of tributaries or occasional projecting hills. These terraces are remnants of the river's flood-plain at the end of the Champlain period. The lower terraces agree less frequently in their height on opposite sides of the river, and are commonly short, seldom extending more than one or two miles, and succeeded by others higher or lower. An examination of them over long distances, however, sometimes shows a well-marked series, descending with the river, and recording a height at which during the process of erosion, the river remained nearly stationary in height for an unusual length of time, forming a broad and continuous flood-plain, now interrupted and nearly swept away by the further deepening of the channel. These terraces are almost always level-topped, and bounded at the face by a steep escarpment; and their appearance is sometimes very striking, and even grand, as they rise in gigantic steps on the side of the valley, shaped with a smoothness, order and beauty, which could not be surpassed by art.

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* It will be seen that these terms are adopted from Prof. James D. Dana, who has given much attention to surface geology, and has brought into due prominence the abundant deposition of drift, both stratified and unstratified, during the Champlain period. See this Journal, III, v, p. 198; x, pp. 168, 280, 353, 409 and 497. These divisions of Quaternary time are well marked in New England, and apparently in all countries, which have been overspread by ice. They are distinctly characterized as successive periods of glaciation, deposition and erosion.

The most interesting discovery made during the survey of this valley is, that a massive gravel ridge, often nearly covered by the alluvium of the highest terraces, extends from Lyme, N. H., to Windsor, Vt., a distance of twenty-four miles. It is principally gravel, always waterworn, the largest pebbles being one to two feet in diameter, with occasional layers one or two feet in thickness of coarse sharp sand. These deposits are very irregularly bedded, and a section always shows a somewhat anticlinal stratification, conforming to the slopes of the ridge. Its height is 150 to 250 feet above the river, by which it has been frequently cut through, as well as by tributary streams. This ridge occupies nearly the middle of the valley, and as the river has cut its channel through the alluvium, this has been often a barrier rising steeply upon one side and protecting the plains behind it. In two or three places it has been swept away by the river for a distance of one half mile to one mile, and below these places the terraces show by their coarseness that the ridge has supplied a portion of their material. Similar ridges of gravel have been often described by European geologists, under the various names of *kames* in Scotland, *eskers* in Ireland, and *åsar* in Sweden. They have also been described by geologists in many portions of the northern United States. In both the Connecticut and Merrimack Valleys they extend long distances, but have hitherto escaped notice, owing to the large amount of levelly stratified alluvium, forming the conspicuous terraces and plains, by which these underlying gravel ridges, or kames, are often nearly concealed. The kames are thus shown by their position to be the oldest of our modified drift deposits.

The series of kames already mentioned lie along the middle or lowest part of the valleys, which are bordered by high ranges of hills; but in the southeast part of New Hampshire, in some parts of Maine, and in eastern Massachusetts, where there are only scattered hills, with the valleys not much below the general level of the country, these ridges, of smaller size than in the great valleys, are found extending usually north and south without special regard to the present water-courses.

The origin of the kames has been a question much discussed by European geologists, and the theory commonly accepted on both sides of the Atlantic was, that they were heaped up in these peculiar ridges and mounds through the agency of marine currents during a submergence of the land. Even if such ridges could be formed by this cause under any circumstances, it seemed impossible to account thus for the kames in the Connecticut and Merrimack Valleys, which, being bordered on both sides by high hills, would have been long estuaries open to the sea only at their mouths, and therefore not affected by oceanic currents. From the position of these peculiar accumulations of gravel, which are overlain by the horizontally stratified drift, the date of their formation is known to be between the period when the ice-sheet moved over the land, and that closely following, in which this more recent modified drift was deposited in the open valley from the floods that were supplied by the melting ice. We are thus led to an explanation of the kames, which seems to be supported by all the facts observed in New Hampshire, and which appears to apply, also, to the similar deposits which have been described in other parts of the United States and in Europe.

At the beginning of the Champlain period, or final melting of the great ice-sheet, its nearly level surface of pure ice lay above our highest mountains. That it overtopped Mt. Washington in New Hampshire, has been recently discovered by Prof. C. H. Hitchcock, the State geologist, who has found transported rocks, and shown that glacial drift, or till, underlies the angular blocks at the summit. The melting of the ice-sheet appears to have taken place mostly upon the surface, which was moulded into basins and valleys; and near the terminal front of the ice, these came gradually to coincide with the contour of the land. Here the surface of the ice became covered with the abraded material which had been contained in its mass, and which was now exposed to the washing of its innumerable streams. Its finer portions would be commonly carried away; and the strong current of the rivers which would be formed near the terminal front of the ice-sheet could transport coarse gravel or even boulders of considerable size. In the lower part of their channels, while still walled on both sides by ice, these glacial rivers deposited materials which had been gathered from the melting glacier. By the low water of winter layers of sand would be formed, and by the strong currents of summer layers of gravel, often very coarse, which would be very irregularly bedded, here sand and there gravel accumulating, and without much order interstratified with each other. Sometimes the melting may have been so rapid that the entire section of a kame may show only the deposition of a single summer, which would then be very coarse gravel without layers of sand. When the bordering and separating ice-walls disappeared, these deposits remained in the long ridges of the kames, with steep slopes and irregularly arched stratification. Very irregular short ridges, mounds, and enclosed hollows resulted from deposition among irregular masses of ice.

The glacial rivers which we have described appear to have flowed in channels upon the surface of the ice-sheet; and the formation of the kames took place at or near their mouths, extending along the valleys as fast as the ice-front retreated. Large angular boulders are sometimes, but not frequently, found in the kames or upon their surface. They appear to have been transported by floating ice. Their rare occurrence forbids the supposition that these deposits were formed in channels beneath the ice-sheet, from which many such blocks must have fallen upon the kames.

The necessity of referring the formation of these gravel ridges to glacial rivers became apparent during the exploration and study of our modified drift in 1875; and in August, 1876, this was announced in a paper "On the origin of Kames or Eskers in New Hampshire."* In this essay it was supposed that these rivers more commonly had their course beneath the ice-sheet, but subsequent examination of the underlying till shows that this was seldom the case, and that the kames were deposited in channels formed on the surface of the ice. Prof. Otto Torell, of Sweden,† had pointed out a division of the till into two members, the lower characterized by its blue color, its compactness and hardness and its glaciated stones; the upper being marked by a yellow and reddish color, comparative looseness of the mass, and its angular or unworn bowlders. This division is found throughout New Hampshire; there being almost always a definite separation, at a depth varying from two or three feet, as is most common, to fifteen or twenty feet, between the upper and lower till. It should be added that the lower till in a majority of cases has no distinct blue tint, but is dark gray; being always somewhat darker than the upper till, which is colored by ferric oxide. The lower till may be distinguished by an imperfect cleavage in planes parallel to the surface, noticeable wherever an excavation has been for a short time exposed to the weather. Before this, Professor James D. Dana had insisted that the deposition of a great part of the till took place in the Champlain period, being dropped from the melting ice-sheet. This suggested the origin of the upper till, and an explanation of its difference from the lower till; the latter being the ground-moraine, while the former appears to have been material contained in the body of the ice-sheet, and allowed to fall loosely on the surface when this melted. As the kames overlie both members of the till, they plainly were deposited in superficial ice-channels.‡

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* Proceedings of the American Association for the Advancement of Science, vol. xxv.

† See this Journal, III, xiii, p. 77.

‡ Similar conclusions respecting the origin of the kames had been reached by other observers, but were unknown to me when my views were proposed in August, 1876. Probably the first of these was Professor N. H. Winchell, State

When the glacial river entered the open valley from which the ice had retreated, its current was slackened by the less rapid descent, causing the deposition successively of its gravel, sand and fine silt or clay. The valleys were thus filled with extensive and thick deposits of modified drift, which took the same slope with the descending floods, increasing in depth in the same way that additions are now made to the bottom-land, or intervals, of our large rivers by the annual floods of spring.

The terraces began to be formed as soon as the supply of material became insufficient to fill the place of that excavated by the river. We must suppose that this process of erosion was slow, allowing the river to continue for a long time at nearly the same level, undermining and wearing away its bank on one side, and depositing the material on the opposite side, till a wide and nearly level lower flood-plain would be formed, bordered on both sides by steep terraces. When the current became turned to wear away the bank in the opposite direction, a large portion of this new flood-plain would be undermined and re-deposited at a lower level; but the direction of the current's wear might be again reversed in season to leave a narrow strip, which would then form a lower terrace.

In placing theories before our description of this valley, their first order has been reversed, since these explanations have been arrived at or confirmed by long study of these deposits in this valley and throughout New Hampshire.

The sources of Connecticut river are a series of four lakes, the highest of which, covering only a few acres, is 2,550 feet above the sea. The lowest of the series is Connecticut Lake, three square miles in area, 1,618 feet above the sea. Heights of the river, with distances from Connecticut Lake, are as follows: Mouth of Hall's stream, 15 miles, 1,085 feet above sea; at Colebrook, 24 miles, 1,010; at North Stratford, 37 miles, 891; at Groveton, 49 miles, 854; at Lancaster, 56 miles, 835; mouth of John's river, 63 miles, 830; at Upper Waterford, 74

Geologist of Minnesota, who held this opinion as early as 1872. See Proc. Amer. Assoc. for Adv. of Science, vol. xxi, 1872, p. 165; Geology of Minnesota, First Annual Report (for 1872), p. 62; and same, Report for 1873, p. 194. In the revised edition of Geikie's Great Ice Age, published in London in the winter of 1876–77, this distinguished glacialist retracts his former opinion that the kames were heaped up by marine currents, and attributes their formation to sub-glacial rivers. See work cited, pp. 217, 237, 240, 243, and 478. By p. 414 it appears that this theory was first proposed by Mr. D. Hummel of the geological survey of Sweden, in 1874; and on page 415 allusion is made to a recent paper by Dr. N. O. Holst, also of Sweden, in which the kames have been explained in the same manner as in this article. On pp. 49 and 50 large rivers are mentioned as having been observed in summer upon the surface of Arctic glaciers. These would be formed on a grander scale in the Champlain period, when the melting of the ice appears to have been much more extensive and rapid than is anywhere to be seen at the present day. The small sub-glacial tunnels which probably existed through the glacial period, would be insufficient to discharge these increased floods, and would become obstructed by the detritus which they brought.

miles, 674; mouth of Passumpsic River, 83 miles, 460; at Wells River, 95 miles, 407; at Hanover, 130 miles, 373; at White River Junction, 134 miles, 333; at Windsor, 146 miles, 304; at Bellows Falls, 170 miles, fall from 283 to 234; at Brattleboro', 192 miles, 200; at South Vernon (Massachusetts line), 202 miles, 180.

The general course of the river to the mouth of Hall's stream is S. 60° W. High wooded hills border the valley which is destitute of modified drift for half of the way. The largest alluvial area is on Indian stream, and the highest terraces are of coarse gravel, 30 to 40 feet above the river.

From the mouth of Hall's stream to that of John's River, at the head of Fifteen-miles Falls, the general course is S. 13° W., with a descent in nearly fifty miles of only 255 feet, one-fifth of which takes place in the first two miles, and two-fifths more in the nine miles between Columbia bridge and North Stratford. Below the first two miles the modified drift is continuous along this whole distance; and, including both sides, it is usually a half mile to one and a half miles wide. It is very simple, having two heights, and consisting of the present flood-plain, bordered by remnants of that which filled the valley in the Champlain period. This ancient flood-plain is represented by a lateral terrace of sand or fine gravel, from 40 to 120 feet above the river, usually remaining at both sides, and in many places forming considerable plains.

At Colebrook we find an interesting gravel ridge or kame, portions of which remain north of the junction of Beaver brook and Mohawk River, but most noticeably west of the village, extending nearly a mile parallel with the river. Its height is about seventy feet above the river, and fifty above the low alluvium on each side. Its material is the same as that of the long kame farther south in this valley, being principally coarse water-worn gravel, with abundant pebbles six inches to one foot in diameter. In Stratford and Brunswick both heights of the alluvium are well shown, the highway being on the upper terrace and the railroad on the meadow. At Lancaster the upper terrace of Connecticut River is only fifteen or twenty feet above the present flood-plain. The only higher modified drift has been brought down by tributaries. Part of Lancaster village is built on one of these deltas, formed by Israel's River on its south side, fifty feet above the terrace of the main valley. This delta sloped rapidly westward, and formerly occupied the whole area of the village; a portion of it, twenty feet lower than the former, remains at the cemetery opposite the court-house.

Between South Lancaster and Fifteen-miles Falls the broad river-plain is unterraced. It seems probable that a lake existed here while the original high plain northward was being deposited. When this was channelled out by the river, so as to leave only terraces as we now see them, the materials excavated were sufficient to fill up the lake. It would be interesting to know the depth of the stratified drift in this basin; it is probably deeper than the height of the highest terraces northward above the river.

From the mouth of John's River, the Connecticut has a rapid descent for twenty miles, falling from 830 to 460 feet above the sea. Its general course is deflected to S. 70° W. along this distance, beyond which the direction of the upper is again followed in the lower valley, with but slight deviation, to Massachusetts line. The noticeable features of the valley along these rapids are, that it is deep and narrow, with sloping sides of till, and destitute of the level alluvial terraces and intervals which occupy a large width everywhere else along the river. Where any modified drift does occur, it is coarser than usual, being generally gravel, sometimes imperfectly rounded or water-worn, and its surface has commonly an irregular slope. The river flows in a nearly continuous descent over coarse till, showing abundant bowlders, but with scarcely any exposure of solid ledges. The falls farther south are produced by ledges; and the channel, except at such falls, is composed of gravel, sand or silt, which is also the case along the nearly level upper valley. The irregular surface left by the ice has been here reduced to a channel of nearly regular slope with no abrupt falls, cut through the till, which still covers the ancient bed in which the river flowed before the glacial period.

In a direct distance of 119 miles from the mouth of Passumpsic River, which is near the foot of these rapids, to the Massachusetts line, the river flows 137 miles, descending from 460 to 180 feet above the sea, or two feet to the mile. The principal falls in this distance are Beard's falls, at Barnet, five feet; McIndoe's falls, ten feet; Dodge's falls, three and a half miles south, five feet; at Woodsville, about ten feet; White River falls, between Hanover and White River Junction, thirty-five feet; Sumner's or Quechee falls, two miles below the mouth of Quechee River, five feet; and Bellows Falls, forty-nine feet, —making a total of 119 feet, and leaving an average descent, excluding falls, of one and one-sixth feet per mile.

The modified drift of this lower valley is everywhere well developed, and occurs in extensive terraces and various heights, three or four often on each side, the upper one being usually from 150 to 200 feet above the river, while the lowest is the interval or meadow. The largest plains are expanses of the upper terrace or of still higher tributary deltas. These areas are generally of a clayey, moist, productive soil quite in contrast with the dry sandy plains of Merrimack River and other parts of New Hampshire. The most extensive intervals or meadows are between Woodsville and Bradford, twelve miles long and one half to one mile wide, including the Lower Coös intervals of Newbury, Haverhill and Piermont; and in Charlestown and Rockingham, six miles long and half a mile wide. In addition to these, smaller areas, up to a mile or more in length and a few rods to a half mile wide, are of common occurrence. These bottom-lands are very fertile, being composed of the finest silt, and enriched every year by a coating of mud from the turbid freshets of Spring. Many of the lower terraces which are not overflowed are of the same material; but the higher terraces usually show some intermixed sand or fine gravel.

The greatest widths of modified drift that can be measured in this valley on the west side of New Hampshire, are in Haverhill and Newbury, two miles, and in Hinsdale and Vernon, two and a half miles wide. The average width is fully one mile. The narrowest places are at Shaw's Mountain, near the south line of Bradford, and at Barber's Mountain, in Claremont, both of which occupy the middle of the valley, with narrow belts of alluvium on each side; at the west side of Rattlesnake Hill, Charlestown; and at the south end of Wantastiquit Mountain, below Brattleboro'. We do not discover, however, at these places or elsewhere, any evidence of former barriers, which could have made the valley a series of lakes. The vast amounts of modified drift which accumulated here appear to have been rapidly deposited from the immense floods supplied by the melting ice-sheet. Such deposits, for which there appears no other adequate cause, should rank with the till, striæ and embossed ledges, as proof of a former continental glacier.

At Woodsville a great depth of material was brought into the valley by the Lower Ammonoosuc and Wells Rivers. The former stream has cut its channel 200 feet deep through its delta, wide areas of which still remain on both sides. An old outlet of Wells River may be seen on its north side, one mile above its mouth, occupied at the close of the ice-period until it cleared away a hundred feet or more of modified drift from the pre-glacial rocky bed in which it now flows. A well marked kame occurs here, commencing in Bath half a mile northwest from the Narrows. It has been cut through by the river, and appears on the east side of the railroad at and above the junction, and again at the southwest side of Wells River Depot, being more than a mile long. It is composed of coarse gravel and sand, anticlinally stratified, with varying height from 80 to 150 feet above the river. It is well shown by cuttings, but otherwise might escape notice, as most of it is partially or wholly concealed by the ordinary alluvium. In the twenty-four miles from Wells River to Lyme no similar ridge is found.

In Thetford and Lyme we come to an abrupt change in the height of the upper terrace-plain. This slopes in thirty-three miles between the mouth of Passumpsic River and the south line of Orford, from 650 to 440 feet above the sea, gradually declining from 190 to only 60 feet above the river. At North Thetford this line of the highest terrace suddenly rises to 525, and in a mile and a half farther south to 545 feet. This formation is well shown through Thetford, with remnants in Lyme, and continues well developed and nearly level for twenty-five miles to Windsor, varying from 560 to 500 feet above the sea, and from 150 to 220 feet above the river. It forms extensive terraces or plains on one or both sides along the whole distance and is clearly the original flood-plain of the river. Frequent delta-terraces rise above it, sometimes 100 feet higher, being more than 300 feet above the present river channel. It is a notable coincidence, that along this same distance we have a continuous kame, occupying the center of the valley, commonly rising somewhat above the highest plain, but not seldom entirely covered by it. Super-position and conformable stratification show the fine material of the terrace-plain to have been deposited upon this kame or gravel ridge, which beforehand extended like a windrow along the empty valley. To the south from Windsor the highest terrace shows a somewhat regular slope, descending with the river, and preserving a height about 150 feet above it.

This high and continuous flood-plain, extending from Thetford to Massachusetts line, seems to have been formed during a gradual and slow melting of the ice along this distance. It would appear that the greater part of the depth of ice, as far northward as to the Passumpsic River, had been melted in the last part of this time, sending down its floods laden with gravel to form the kame. A comparatively shallow mantle of ice remained, and when the melting advanced to the north from Thetford and Lyme this disappeared too rapidly to give time for the formation of a kame, or the deposition of a high flood-plain.

In Norwich we find an interesting example of a well marked ancient river-bed high above its present level. This extends two miles from Pompanoosuc River, one-third of a mile above its mouth, to the bend of Connecticut River a half mile south of Tilden pond, which occupies a depression of this old channel. Its highest point, from which there is a gradual descent both ways, is 520 feet above the sea or 145 feet above the river. On the east side of this ancient channel is the steep gravel kame, which for a while turned the Pompanoosuc River in this course, till a direct passage was cut through its ridge.

Two miles north of Hanover the Connecticut River has cut through the kame, and thence flows close on its west side to White River Falls. Along this distance of four miles we find the high plain well developed in New Hampshire, averaging three-fourths of a mile wide. Hanover common, 545 feet above the sea, and 172 above the river, represents its greatest altitude. In digging the first well at this place (near the residence of Professor H. E. Parker), a large log was found in this alluvium forty feet below the surface, but no prospect of water, which caused this site, selected for the buildings of Dartmouth College, to be abandoned, and led to their location farther east, upon coarse glacial drift. This log shows that the glacial age had here been succeeded by a temperate climate, under which forests grew again upon the land; and that floods, sent out freighted from the melting ice-sheet, which still remained farther north and on the highlands, brought down drift-wood to be buried with their alluvium. It was not till considerably later that the river ceased its work of accumulation and began to cut its present channel.

Near the south line of Lebanon, east of Sumner's Falls in Plainfield, and at several places in Cornish, we find banks of sand, or dunes, destitute of vegetation, and blown in drifts by the wind. These vary in height from a few feet to 100 feet above the highest terrace, from which they appear to have been carried up by the prevailing northwest winds. Southward through New Hampshire they are found in many places on the east side of this valley, but none were seen in Vermont.

From Lyme to Windsor we find a continuous gravel ridge or kame, extending twenty-four miles along the middle of this valley, with its top from 150 to 250 feet above the river, or from 500 to 600 feet above the sea. The gravel, which always forms the principal part of the ridge, varies in coarseness from layers with pebbles only one or two inches in diameter, to portions where the largest measure one and a half or two feet. The finer kinds prevail; and the channels of brooks cutting through the ridge frequently show no pebbles exceeding one foot in size. All the materials of this kame, and of its remnants southward, are plainly water-worn and stratified.

Large and unworn bowlders, which could not have been brought in the same way with the gravel and sand, occur very rarely upon or in the Connecticut kame. The only instance of this discovered was three fourths of a mile south of Pompanoosuc River, at the point where the kame reaches its greatest height above the sea. Two angular bowlders, each of five feet dimension, were found here at the top of the ridge, one lying on the surface, and the other partly imbedded. Several miles at least of journey on foot along the top of this ridge, and the examination of many sections where the river or its tributaries have cut through it, failed to reveal other bowlders of this kind.

One or both sides of this kame are generally covered by the alluvium of the upper terrace; but its top usually projects in a long, rounded ridge, 10 to 30 feet above the adjoining highest plain. At one place, east of Hartland Depot, this plain has been swept away from both sides, and the kame forms a conspicuous steep ridge 125 feet in height. Wherever it is exposed, it is readily recognized by the pebbles which strew its surface, and which are very rarely found in the ordinary modified drift of the valley.

The most important feature of this kame, if we compare it with others in New Hampshire, is, that along its entire extent it constitutes a single continuous ridge, which runs by a very direct course nearly in the middle of the valley, having no outlying spurs, branches, parallel ridges, or scattered hillocks of the same material associated with it. In calling it continuous from Lyme to Windsor, however, it is not meant to imply that it is now entire, since it has been frequently cut through and considerable portions swept away by the main river and by tributary streams; but that so much of it remains as to make it certain that it originally formed an unbroken ridge. The portions now separated by gaps always lie in a continuous line.

Probably a similar ridge once existed along the valley southward, though now shown by only a few fragments. These occur in Charlestown between Springfield Depot and the Cheshire bridge; at Bellows Falls, where a remnant forms the pine-covered plateau, used as a picnic ground, in the north part of the village; in Dummerston, a third of a mile southwest from the depot; and in Brattleboro', at the north side of West River, lying on ledges between the railroad and highway.

Near Bellows Falls, Cold and Saxton's Rivers have brought down large amounts of modified drift seventy-five feet above the normal high plain. The delta of the former has been eroded so far as it occupied the main valley, but the escarpments thus formed remain at the mouth of the valley of Cold River, from 100 to 200 feet high.. On the south side of Saxton's River a considerable part of its delta remains, and the upper terrace is increased in height by this cause for two miles south. The excavation of this delta by Saxton's River has formed a most interestingly terraced basin, situated less than a mile south from Bellows Falls Junction. On both sides of this river, and crossed by a road, is an interval about one fourth of a mile in diameter. Around this on all sides are ranged terraces, which rise in succession like the seats of an amphitheater, the highest on the northwest being 220, and on the south 200 feet above the arena below. They do not, however, show a perfect regularity either in correspondence of height or in continuous extent, and no single section would embrace all of the eight distinct and separate terraces which were noted on each side of the river.

The most extensive plain on Connecticut River in New Hampshire or Vermont is in Hinsdale, being three miles long, with a width decreasing from two miles to two-thirds of a mile. The road from Hinsdale to Brattleboro' passes over the south end of this plain. Here its height is 350 feet above the sea, or 165 above the Connecticut at the mouth of Ashuelot River. It is mainly composed of sand, nearly level, but with a slight slope to the west and south, being as usual towards the river and in the direction of its course. Its northern portion changes to gravel which becomes coarse on the southeast side of Wantastiquit Mountain, containing pebbles one foot or sometimes a foot and a half in diameter. The position and slope of this plain show that it was not deposited wholly from currents of the main valley, but that a considerable portion was contributed from the melting of the ice-sheet east of this mountain.

ART. L.—*Descriptions of two new species of Fishes* (*Macrurus Bairdii and Lycodes Verrillii*) *recently discovered by the U. S. Fish Commission, with notes upon the occurrence of several unusual forms;* by G. BROWN GOODE and TARLETON H. BEAN.

AMONG the many interesting discoveries made during the present summer by the United States Fish Commission (Prof. S. F. Baird, Commissioner) is that of a species of *Macrurus* believed to be undescribed. A single specimen was taken in a trawl net, August 19, 1877, on the voyage of the U. S. Steamer "Speedwell" from Salem to Halifax. It was found in the Gulf of Maine, forty-four miles from Cape Ann (east ½ south) in 160 fathoms, muddy bottom (locality 35). Two members of this family are included by Professor Gill in his Catalogue of the Fishes of the East Coast of North America (Washington, 1873). One, *Coryphænoides norvegicus*, has been recorded only from Greenland and the northern and western coasts of Norway. The other, *Macrurus rupestris*, has much the same geographical range: a fish found floating at sea near Gravesend, N. Y., in 1876, and now in the U. S. National Museum, has been identified with this species.

The genus *Macrurus*, auct., has been subdivided into three, viz: *Macrurus*, *Coryphænoides* and *Malacocephalus*. The most important diagnostic character given by Dr. Günther as separating *Macrurus* from the other genera is the joining of the ridge of the suborbital ring to the angle of the preoperculum as in *Scorpænidæ* and *Cottidæ.* This character does not hold good in the species here under consideration, which in all other respects agrees with *Macrurus*, as defined in Günther's Catalogue of Fishes in the British Museum.

The closest affinities of *Macrurus Bairdii* are with *M. sclerorhynchus*, described by Valenciennes from the Canary Islands. Its relations to this species and to the other representatives of the family in North America are shown in the following table:

	Macrurus Bairdii.	*Macrurus sclerorhynchus.*	*Macrurus rupestris.*	*Coryphænoides ? norvegicus.*
Snout.	Sharp, conical, quadrate, shorter than eye, less than one-third of head.	Sharp, trihedral, shorter than eye, which is two fifths of head.	Sharp, triangular, as long as eye.	Obtuse, obliquely truncated.
First Dorsal.	Second spine denticulated from base to tip, not extending to origin of second dorsal.	Second spine denticulated, extending far beyond origin of second dorsal.	First spine denticulated only towards the top.	First spine denticulated anteriorly.
Vent.	Under middle of first dorsal.	Behind vertical from last ray of first dorsal.	Behind vertical from origin of second dorsal.	Before vertical from origin of second dorsal.
Scales.	Spiny. Median row of spines forming keel upon scales of head and upper anterior portion of body.	Spiny. Median row of spines forming keel.	Each with a strong longitudinal keel terminating in a point.	Spiny, without keel.
Transverse rows of scales	6 + 19 or 20.	5 + 21 or 23.	5 +	4 or 5 + .
Radial formulæ.	D. II. 11. 137. A. 120. V. 7.	II. 9 or 11. 87. 72.	11. 124. 148. 8.	11 + . 8.

Macrurus Bairdii, sp. nov.

Extreme length of specimen described,* 0·296 m. (11·7 inches). Body tapering from first dorsal to tip of tail, much compressed posteriorly, its greatest height over origin of pectorals (0·037 m.) contained eight times in length; its greatest width at same point (0·022 m.), contained 13 times in length.

Scales irregularly polygonal, the free portions covered with transparent, vitreous spines, arranged in from ten to twelve irregular longitudinal rows. On head, and upper part of body, in advance of first dorsal, the median row of spines is the most prominent, and presents the appearance of a low median keel.

Lateral line nearly straight, formed by a smooth groove which replaces two or three median rows of spines of each scale. Number of scales in lateral line, 152; six transverse rows aboye it, and nineteen or twenty rows below it, counting from vent obliquely backward.

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* Cat. No. U. S. National Museum, 21,014.

Head.—Greatest length (0·045 m.) equals distance between first and twenty-third anal rays, and is contained six and one-half times in extreme length. Greatest height, at posterior margin of orbit, (0·028 m.) greater than width at same point (0·023 m.), and contained one and four-seventh times in length of head. Width of interorbital area (0·012 m.) equal to vertical diameter of orbit (0·012 m.), and almost equal to length of snout (0·013 m.) and length of maxillary (0·013 m.). Length of post-orbital region (0·017 m.) about equal to horizontal diameter of orbit (0·016 m.). Length of operculum (0·007 m.) about half the length of mandible (0·015 m.).

Snout sharp, a front view presenting four ridges radiating from the tip at right angles to each other, the lower one being merely a fold in the skin of the under surface of the head. The horizontal ridges are continued into the ridges upon the suborbitals. Ridge extending backward from tip of snout upon top of head is lost in the interorbital space. Branches of the horizontal ridges are continued upon the upper margins of orbits, and there disappear. Nostrils immediately in front of orbit, the posterior pair much the longer.

Mouth situated entirely on lower side of head; symphysis of lower jaw in vertical from anterior margin of orbit, and articulations of mandibles in vertical from posterior margin of orbit; width of cleft of mouth (0·012 m.) equal to distance between symphysis of maxillaries and line connecting their articulations. Upper jaw protractile vertically. Barbel 0·005 m. in length.

Teeth conical, somewhat recurved, of nearly uniform size, arranged in villiform bands. Palate smooth.

Distance of first dorsal from snout (0·057 m.) about four times the length of its base (0·014 m.), and from anterior margin of orbit equal to length of head. First spine very short (0·002 m.), not much longer than the teeth of second spine. Second spine in length (0·032 m.) twice horizontal diameter of orbit, stout, its anterior margin armed from base to tip with fifteen teeth pointing upward, the uppermost being longest and most slender: its length to tip of filament (0·037 m.) is almost equal to distance from origin of first to origin of second dorsal (0·038 m.), this tip when laid back reaching almost to second dorsal. Rays decreasing regularly in length so that, when the fin is upright, its shape approximates that of a right angled triangle, the hypothenuse of which is the second dorsal spine and its perpendicular side a line touching the tips of the rays.

Length of base of second dorsal (0·204 m.) less than that of the anal, its origin over the 30th scale of lateral line. Length of longest ray (in posterior third) 0·004 m., which is less than length of barbel. All rays very feeble. Membrane scarcely perceptible.

Distance of anal from snout (0·070 m.) three and four-fifth times in its length of base, its origin under 18th scale of lateral line. Length of first ray (0·006 m.) one-half the length of tenth ray (0·012 m.), and three times the length of last ray (0·002 m.), the length of rays increasing to a point beneath anterior part of first dorsal, and thence gradually decreasing to tip of tail.

Distance of pectoral from snout (0·048 m.) four times width of interorbital area; its length (0·029 m.) twice the length of mandible. Insertion above the middle of the depth of the body, on a level with center of orbit, its third ray longest, its tip reaching to vertical from base of fourth anal ray.

Insertion of ventral behind pectoral and almost under that of first dorsal; its distance from snout (0·053 m.) slightly exceeding twice its length (0·025 m.). Tip of ventral filament reaches to base of third anal ray.

Radial formula: D. II, 11. 137; A. 120; P. 15; V. 7.

Color: Ground color, light brownish gray; under parts, silvery; belly, darker, bluish. Under surface of snout, pink, as is also the first dorsal except spines. Spines of dorsal, ventral and anterior anal rays, blackish. Throat, branchiostegal membrane and isthmus, rich deep violet. Sclerotic coat, green. Eyes, very dark blue.

Spermaries well developed, but milt not mature. Individual apparently adult.

This species is dedicated to Professor Spencer F. Baird, LL.D., Assistant Secretary of the Smithsonian Institution, Director of the U. S. National Museum and U. S. Commissioner of Fish and Fisheries.

Another interesting form is a species of *Lycodes* taken in the trawl thirty miles south of Cape Negro, N. S. (localities 44 and 45), in ninety fathoms, fine sand and mud bottom, and twenty-seven miles south of Chebucto Head, Halifax, (locality 83) 101 fathoms, fine sandy mud. Five specimens (Cat. No. U. S. Nat. Mus. 21,013) were taken in the first locality and one (No. 21,015) in the latter.

Eleven species of this genus have been described, eight of which are found in arctic seas, three in antarctic, the latter being separated by Dr. Günther into a distinct section of the genus. The form under consideration is distinguished by (1) its elongated form, which it shares, with *L. Sarsii;* (2) the great proportional length of the maxillaries; (3) by the presence and arrangement of scales; (4) by various proportions of parts which distinguish it from one or all the allied species; (5) the presence of five rays in the ventral fin, and; (6) by coloration.

Lycodes Verrillii, sp. nov.

The extreme length of specimen described 0·127 m. (five inches).

Body more elongate than in any other described species of that section of the genus occurring in arctic seas, except *L. Sarsii* Kroyer: its greatest height (0·010 m.) equal to its greatest width between pectorals (0·010 m.) and nearly one-thirteenth of its total length.

Distance of vent from ventrals (0·023 m.) slightly greater than length of head (Om. 022), which is contained about five and two-third times in total length. Distance of vent from snout (0·041 m.) about one-third length of body.

Head, body and fins enveloped in tough lax skin.

Scales cycloid, circular and ovate, 0·00025 m. to ·00035 in diameter, with numerous concentric striæ, and with about eighteen lobes upon margin, the whole perrimeter being lobed: they are deeply imbedded in the skin at distances from each other equal to their own diameters: they are most numerous upon the upper half of the body, and extend upon the base of the dorsal; very few upon the lower half of the body; and are absent from the anal fin.

Head much depressed, its width (0·014 m.) considerably greater than its height (0·010 m.) which equals length of post-orbital portion of head (0·010 m.) and double the width of the inter-orbital space (0·005 m.). Length of maxillary (0·011·m.) is half the length of the head (0·022 m.): the maxillary extends nearly to the perpendicular from the posterior margin of the orbit. Diameter of orbit (0·004 m.) is half the length of snout (0·008 m.).

Viewed from above the snout is somewhat obtusely rounded, and a line drawn through the center of the eyes would form with the sides of the snout a figure approximating in shape an equilateral triangle, the angle of the snout being rounded.

Upper jaw far overlapping under jaw; gape extending from ventral to center of orbit.

A series of large pores, six on each side, extends backward from nostril toward angle of operculum, following line of upper jaw at a distance above it about equal to diameter of pupil. The fourth of this series, counting backward, is under the center of orbit, the last is situated about two-thirds of the distance from snout to angle of operculum.

A similar series, seven on each side, follows line of lower jaw from its symphysis obliquely upward toward angle of operculum, in such direction that if the maxillary row were continued by the addition of a single pore to the series, the two lines would intersect. A line connecting the fourth pore of the one series with the fourth pore of the other would intersect the articulation of the jaws. The first four pores of the mandibular series are slit-like; all the others in both series are circular or nearly so, their diameter equal to one-third to one-half that of the pupil. The profile of the head resembles that of *Zoarces anguillaris;* the top of the post-orbital tract is on a level lower than that of the top of eye, the outline of the head then rising to a point over the center of the orbit, thence sloping abruptly to the snout.

Cleft of mouth horizontal, in width equal to post-orbital length of head (0·010 m.), also to distance from snout to angles of gape.

Nostrils at extremities of fleshy tubes, the length of which is equal to the diameter of the largest pores.

Teeth in lower jaw in two rows and nearly uniform in size, in upper jaw, in a single row, some larger ones near symphysis with patches of smaller ones behind them. About seven teeth on the vomer. A single row of teeth on palatines. All the teeth are curved.

Gill openings narrow; gill membranes attached to isthmus.

Distance of dorsal from snout (0·033 m.) one and one-half times the length of head (0·022 m.).

Distance of anal from snout (0·045 m.) twice the length of head.

Dorsal and anal fins are about equal in height, with even margins, not differentiated from caudal; the rays increase somewhat in length toward extremity of tail, though the fins do not increase in height.

Distance of pectoral from snout (0·023 m.) about equal to length of head, twice length of pectoral (0·011 m.) and more than three times breadth (0·007 m.). Pectoral extends to vertical from base of second dorsal ray.

Distance of ventrals from snout (0·021 m.) less than length of head (0·022 m.), their length (0·002 m.) less than one-fourth the length of pectorals, placing this species in the first section of the genus as defined by Dr. Günther.

Radial formula: D, 92; A, 88; P, 15; V, 5. Color: Body above lateral line light grayish brown with numerous minute circular dots marking the position of the scales; below lateral line pearly white. Brown irregular patches upon the sides, bisected by the lateral line, the part lying below lateral line is of the dorsal hue, that above a darker shade of the same color, and exhibiting the white dots already described. These brown patches are seven to ten in number on each side, in some specimens regularly alternating with each other, in others approximating each other in such manner as almost to form broad irregular bands across the back. A spot of brown upon the tip of tail. Abdominal region livid blue In a very small specimen* the brown patches are for the most part circular and are not confluent over the back.

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* 21,015 of the U. S. National Museum Catalogue.

Four of the six specimens taken had a lernean parasite on the gills.

This species is dedicated to Professor Addison E. Verrill, of Yale College, who has been in charge of the invertebrate work of the U. S. Fish Commission since its organization.

In addition to the above species a number of new or unusual forms have been taken or observed, among which may be specified the following:

Alutera cuspicauda Dekay. A specimen of this species which has not before been recorded north of Cape Cod, was taken in Halifax Harbor, September 6.

Euchalarodus Putnami Gill. Several specimens of this uncommon species, which had been taken in Salem harbor in winter, were found in the collection of the Peabody Academy of Sciences.

Myzopsetta ferruginea (Storer) Gill. Taken in Massachusetts Bay in forty-five to ninety fathoms; near La Have Bank in ninety fathoms; and at the mouth of Halifax Harbor in sixteen to eighteen fathoms.

Pleuronectes glaber (Storer) Gill. Several specimens, taken in Salem Harbor, Mass., were noted in the collection of the Peabody Academy.

Glyptocephalus cynoglossus (Linn.) Gill. This fish, the Craig Flounder or Pole of Europe is cited by British authors as one of the rarest of arctic flounders. It has hitherto been unknown to the coast of North America. At least one hundred specimens have been secured, representing great variety of form, age and other conditions. The species was first taken August 6, 1877, off Salem in forty-five fathoms. It has since been secured near La Have Bank in eighty-eight fathoms, and in Bedford Basin, Halifax, in from twenty-five to thirty-five fathoms.

Hippoglossoides platessoides (Fabr.) Gill. Taken on La Have Bank in eighty-eight fathoms. Heretofore recorded only from Greenland. It is not identical with *H. limandoides* as suggested by Dr. Günther.*

A species of the genus *Hippoglossoides* which is distinct from *H. platessoides* and may prove to be identical with the *H. limandoides* of Günther has been taken in company with *Glyptocephalu scynoglossus* in Bedford Basin, Halifax.

Rhinonemus caudacuta (Storer) Gill. Several specimens taken in Massachusetts Bay, and on La Have Bank.

Cryptacanthodes maculatus Storer. One specimen taken in Massachusetts Bay, August 13, 1877, in forty-eight fathoms.

Eumesogrammus subbifurcatus (Storer) Gill. A single specimen was taken August 25, 1877 in the mouth of Halifax Harbor in sixteen fathoms.

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* Cat. Fish. Brit. Mus., iv, 1862, p. 405.

Stichœus punctatus (Fabr.) Reinh. A single specimen of brilliant scarlet color, was taken in the same locality with the preceding.

Eumicotremus spinosus (Fabr.) Gill. One specimen was dredged by the U. S. Fish Commission six miles off Half Way Rock, Salem, Mass., August 10, 1877, in thirty-five fathoms. "It is of very rare occurrence. Two specimens were dredged in 1861 by Professor Verrill, off Anticosti in ten fathoms, and another was taken by U. S. Fish Commission at Eastport, (Maine), in 1872." (*Putnam.*)

Aspidophoroides monopterygius (Bloch) Storer. Up to the time of the visit of the U. S. Fish Commission to Salem, this species has been very rarely taken south of Greenland, and that mainly from the stomachs of cod, haddock, halibut and other fishes. Several specimens were dredged by the Commission at Portland and Eastport, Maine. Many specimens were taken in Massachusetts Bay, often a dozen coming up in a single haul of the trawl.

Icelus uncinatus Reinhardt. Trawled in considerable numbers in Massachusetts Bay in forty-two to ninety fathoms. One or two were secured by the U. S. Fish Commission at Eastport, Maine, in 1872. No other specimens are known to have occurred on the coast of North America.

Triglops, sp. An undetermined member of this genus, has been taken in deep water in several localities.

Fistularia serrata Cuv. Specimens from Massachusetts Bay are in the museums of the Boston Society of Natural History and the Peabody Academy, Salem; also one from the Western Atlantic in the Colonial Museum at Halifax. Later writers have excluded this species from the fauna of North America, following the lead of Dr. Günther who gives its distribution as exclusively Indo-Pacific. A specimen taken by J. Matthew Jones, Esq., in Bermuda, was identified by Dr. Günther with *F. serrata.* This species must be restored to the faunal relations claimed for it by the earlier American authors, to whom Dr. Günther makes not the slightest reference in his synonymy.

Raia radiata Donovan. This species is well described by Fabricius under the name of *Raia fullonica.* Adults and young have been taken sparingly in Massachusetts Bay, on La Have Bank, in Halifax Harbor, and in Bedford Basin.

Canthorhinus occidentalis (Gthr.) Goode. A specimen of this fish, not before recorded north of Bermuda and Key West, was taken in the summer of 1875 at Linen Island near the entrance to Chesapeake Bay, and presented to the National Museum by Captain John Evans.

Hypeneus maculatus (Bloch) Cuvier. A specimen was taken at Wood's Holl, Mass., July, 1877, by Vinal N. Edwards. The species occurs in Bermuda, the West Indies, and on the coast of Brazil.

Chilichthys Spengleri (Bloch) Goode. A single individual was taken by Vinal N. Edwards at Wood's Holl, in August, 1877. A West Indian and Madeiran form.

Lactophrys trigonus (Linn.) Poey. Ten or twelve individuals were taken at Wood's Holl, 1877. The species has only once before (in 1833) been taken north of Florida.

ART. LI.—*Volumetric Determinations by Chromic Acid;* by C. W. HINMAN.

IN the early part of the year 1870, while a student at the Institute of Technology, Boston, I endeavored to devise a volumetric assay of lead ores, especially galena. The process first used was briefly this: The finely pulverized ore was decomposed by strong nitric acid and the resulting lead sulphate dissolved by ammonium acetate. The lead solution was then titrated by a standard solution of potassium bichromate, using silver nitrate as an indicator: reddish brown silver chromate being formed as soon as the lead was all precipitated. This process of titration was first given by H. Schwarz, (Dingl. polyt. Journ., clxix, 284). This method worked fairly well except that the reaction at the end was not sufficiently delicate. It has since been recommended by F. Maxwell Lyte (Chem. News, xxx, 298). While searching for a more delicate indicator I found that a drop of a mixture of starch paste, potassium iodide, and some acid would be turned blue by a very small quantity of bichromate; also by suspended lead chromate when the ordinary strong acids were used. But if the mixture was acidified by a solution of one part crystallized citric acid to six of water, lead chromate gave the blue color only after the lapse of some minutes, while bichromate gave it immediately. Quite a number of analyses of pure lead nitrate were made by one of the present professors and myself, using the indicator just described; and the results were quite satisfactory. On trying to use the method in titrating the solution of lead sulphate in ammonium acetate it was found that no blue coloration was produced until there was quite an excess of bichromate present. This was owing to the amount of ammonium salts present, but a number of other substances have the same effect. I then abandoned the process. Th. Rosenbladt (Jahresbericht f. Chemie, 1875) recommends a similar indicator for chromic acid in estimating the quantity of sulphuric acid in drinking water.

During the last few years I have had occasion to make a large number of determinations of the quantity of sulphur in coal gas, and have often wished for some process of determining sulphuric acid less tedious than the ordinary gravimetric one by barium sulphate and more accurate than the volumetric methods in ordinary use; and nearly a year ago I began some experiments to find such a method. Sulphuric acid can be determined by means of chromic acid, and the latter is reduced by quite a number of reagents. I had previously found a delicate test for chromic acid in the acid solution of starch paste and potassium iodide. It remained to be seen if the blue color disappeared as soon as the chromic acid was all reduced. I found that of the ordinary reducing agents only an acid solution of stannous chloride produced this result, even when a large excess of acid was present. I found that a given quantity of potassium bichromate and water always required the same quantity of stannous chloride, but the larger the quantity of water the more stannous chloride was required. This was accounted for on the supposition that the oxygen dissolved in the water was acted on before the chromic acid was all reduced. It was finally found desirable to boil the bichromate solution and cool it out of contact with the air; when this was done the quantity of water present made no difference in the amount of stannous chloride required. The following are the details of the process. The chromate is weighed or measured into a small flask which is then filled with water nearly to the neck. The flask is closed with a stopper through which passes a glass tube, at the end of which is a rubber valve opening outward. The contents of the flask are boiled for some minutes and then cooled; the valve preventing the access of air. A few centimeters of hydrochloric acid are added and then stannous chloride from a glass cock burette until the color is nearly pure green, but taking care to leave a little chromic acid unreduced. A few drops of a mixture of starch paste and potassium iodide added to the contents of the flask produces a dark blue color which is to be removed by the cautious addition of stannous chloride. The exact point is easy to hit as at last the color changes rapidly with a small addition of the chloride. The following determinations were made in this manner, a standard solution of potassium bichromate containing 14·761 grams per liter being used.

$K_2Cr_2O_7$	$SnCl_2$	Ratio.
25 cc. req.	19·26 cc.	·770½
13	10·04	·772
10	7·72	·772
10	7·73	·773
3	2·33	·777
3	2·32	·773
3	2·34	·780

Of course bodies like ferric and cupric salts that are reduced by stannous chloride must be absent and the solution must not be so concentrated that the green of the chromic chloride obscures the iodo-starch blue. Stannous chloride has had the reputation of changing rapidly on standing, but I have found it quite stable, when properly protected from the air, as the following results show:

March 9, 10 cc. potassium bichromate required, 7·74 cc. stannous chloride.
" 12, " " " " 7·72–3 " "
April 16, " " " " 7·73–4 " "
May 21, " " " " 7·74 " "

The following determinations can be made by means of chromic acid. The chromates of lead, barium, and bismuth can be accurately precipitated, barium from an ammonical solution, the others from an acetic solution. The determination of lead is given as an example.

Twenty-five cc. of a solution of lead acetate, fifty cc. of which gave 0·5908 gram lead sulphate, were diluted with water and a little acetic acid, heated to boiling in a small beaker and 10 cc. standard bichromate solution added. The precipitate of lead chromate was filtered off after standing a few minutes, washed, and the excess of chromic acid determined in the filtrate. The quantity of stannous chloride required was 0·20 cc.; other experiments gave 0·21, 0.21, 0·20, and 0·20, by calculation from the amount of lead sulphate there should have been required 0·19 cc. being an error of one or two parts in about 750.

If a known quantity of bichromate is added to acid solutions of arsenious or antimonious acids they will be oxidized to arsenic and antimonic acids and the excess of chromic acid can then be determined. Twenty-five cc. of a solution of arsenious acid, containing 5·2675 grams per liter, plus 10 cc. standard bichromate solution, required 1·36, 1·35, 1·33, and 1·35 cc. of stannous chloride. If the arsenious acid had been pure only 1·22 cc. stannous chloride would have been required instead 1·35. In other words the arsenious acid contained about one and four-tenths per cent impurity. The only antimony compound I happened to have at hand was tartar emetic, but tartaric acid in that seemed to interfere with the reaction to a certain extent so that the results were not satisfactory.

Sulphuric acid can be determined as follows: To a slightly acid solution of a sulphate heated to boiling is added a small excess of a solution of barium chromate in hydrochloric acid, barium sulphate is precipitated; then the solution is neutralized with ammonia which precipitates the remaining barium chromate, the precipitates of barium sulphate and chromate are filtered off and the chromic acid determined in the filtrate is equivalent to the sulphuric acid in the original solution.

H_2SO_4 sol.	$SnCl_2$ sol.	Calculated.
3 cc. req.	1·87 cc.	1·85 cc.
5	3·10	3·08
10	6·16	6·15
25	15·38	15·37

Twenty-five cc. of the sulphuric acid solution gave 0·4633 grams barium sulphate.

Perhaps the oxygen in drinking water can be determined by means of the chromic acid method, but my experiments are as yet incomplete.

Having worked for some time with the method of estimating iron by means of stannous chloride, I am convinced that its importance is not yet recognized generally. The following modification seems to simplify the process as given in the last edition of Fresenius' analysis. To the iron solution which has just been decolorized by stannous chloride, add a small pipette full of iodine solution, equivalent to about one-fourth cubic centimeter of stannous chloride, cool, then add a little starch paste and stannous chloride until the color disappears. The equivalent in stannous chloride of the pipette of iodine solution substracted from the whole amount used leaves the quantity required by the iron. By this means the use of a second burette is avoided and less calculation is required.

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SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Gases enclosed in Lignite.*—Thomas, in continuation of his researches upon the gases enclosed in coals, has examined with this view the lignites of Bovey Heathfield, Devonshire, and also a specimen of mineral resin, the "retinasphaltum" of Hatchett. A leafy lignite weighing 100 grams, on being kept in a Sprengel vacuum at 50° for twelve days, evolved 56·1 c.c. of gas, consisting of CO_2 87·25, O 0·24, CO 3·59 and N 8·92=100. It was then kept at 100° for eighteen days, and evolved 59·9 c.c. of gas, of which 89·53 was CO_2, 0·33 C_nH_{2n} gases, 5·11 CO and 5·03 N. At a higher temperature, decomposition set in, evolving H_2S and apparently allyl sulphide, mixed with the gaseous products. The gas evolved at 250° contained H_2S 5·85, CO_2 71·13, C_nH_{2n} 1·09, CO 16·20, CH_4 5·46, N 0·27=100. The mineral resin gave no gas at 50°, but at 100° yielded 21·4 c.c. of gas for each 100 grams of resin, consisting of CO_2 88·24, O 0·23, C_nH_{2n} gases 0·47, CO 7·90, N 3·16=100. On further heating the resin began to melt, and decomposition set in at 110° to 112°, the gases collected below 150° consisting of H_2S 0·41, CO_2 78·88, C_nH_{2n} gases

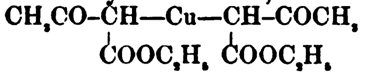
2·67, CO 7·82, CH_4 8·05, C_2H_8 1·86, nitrogen 0·31=100. Compared with the coals proper, lignites show therefore a marked difference in their gaseous contents, approaching most nearly, however, the cannels. But while the greater portion of the gas enclosed in both cannel and lignite consists of CO_2, the former contains the gases and other compounds of the paraffin series and the latter C_nH_{2n} gases as well as oily aromatic bodies and CO. Moreover lignites decompose much easier than coals.—*J. Chem. Soc.*, xxxii, 146, Aug., 1877. G. F. B.

2. *On the Reaction between Insoluble Carbonates and Soluble Oxalates.*—WATSON SMITH, observing that ammonia was evolved on mixing ammonium oxalate and chalk or marble powder, repeated the experiment with sodium oxalate, and obtained even in the cold a distinctly alkaline reaction. On heating the two substances together and then filtering, the filtrate effervesced on adding hydrochloric acid. This led to a series of experiments to determine the character and extent of this reaction, and to compare it with that of alkali carbonates upon the earthy oxalates. Regarding the possible Na_2CO_3 formed when the decomposition is complete as 100, calcium carbonate treated with sodium oxalate gave 19·83 Na_2CO_3 in the cold and 22·90 when heated; strontium carbonate gave 7·63 in both cases; barium carbonate gave 4·84 and 4·98; and lead carbonate 6·35 and 13·08. Conversely, if 100 represent the possible Na_2CO_3 converted into oxalate, calcium oxalate converted 16·07 in the cold and 52·34 when heated; strontium oxalate 57·24 and 79·96; barium oxalate 73·20 and 87·96; and lead oxalate 81·54 and 90·61. In the cold, calcium carbonate is as much more acted on by sodium oxalate than is barium carbonate, as barium oxalate is by sodium carbonate more than calcium oxalate. In the case of soluble oxalates, the reaction does not appear to be facilitated materially by heat.—*J. Chem. Soc.*, xxxii, 245, Sept., 1877. G. F. B.

3. *On the new Metal Davyum.*—In the month of June last, Sergius Kern succeeded in isolating a new metal belonging to the platinum group, to which he gave the name Davyum, in honor of Sir Humphrey Davy. To prepare it, 600 grams of the platiniferous sand were treated by Bunsen's method for the separation of the platinum, iridium, rhodium, osmium, palladium, ruthenium, iron and copper which it contained. The mother liquors after the separation of the rhodium and the iridium were heated with an excess of chloride and nitrate of ammonium. A dark red precipitate was obtained, which, calcined at a red heat, gave a grayish mass resembling platinum sponge; and this, fused by the oxyhydrogen flame, gave a silver white ingot weighing 0·27 gram, and having a density of 9·385 at 25° C. The metal is hard and malleable at a red heat; it is easily attacked by aqua regia and feebly by boiling sulphuric acid. Potassium hydrate precipitates its solutions yellow. Hydrogen sulphide gives a brown precipitate in solutions of davyum chloride, which changes to black on drying. Potassium sulphocyanide colors this solution red, like

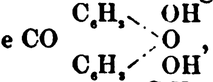
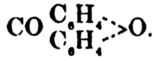
ferric salts, when dilute, and gives a red precipitate when concentrated. In Mendelejeff's classification, the author thinks davyum is the hypothetical element placed between molybdenum and ruthenium.

In a subsequent paper, Kern gives the reactions of the new metal obtained by dissolving his ingot in aqua regia. The yellow hydrate is readily soluble in acids, even in acetic. The nitrate appears as a brown mass, which on calcination gives a black monoxide. Dissolved in potassium cyanide, davyum chloride gives beautiful crystals of a double cyanide. Cyanodavic acid is very unstable. The sulphide is soluble in alkali sulphides, giving sulphosalts. The sulphocyanide crystallizes in large crystals, and becomes black on heating. The chloride is soluble in water, alcohol and ether, and its crystals are not deliquescent. It forms double chlorides easily, that with sodium being almost insoluble in water and alcohol. No second chloride is known. New determinations give the density 9·389. Its atomic weight has not yet been determined, but it is probably between 150 and 154.—*C. R.*, lxxxv, 72, 623, July, Oct., 1877. G. F. B.

4. *Upon Metalacetyl-acetic ethers.*—CONRAD has extended the law that negative radicals are found in a molecule in the vicinity of negative groups, by supposing that the energy of the carbon is so raised by the presence of negative radicals, that the hydrogen combined with it may be replaced by positive atoms. In proof of this he shows that a salt obtained by Geuther and supposed by him to have its metal atoms united to the carbon by oxygen, has them in fact united directly to the carbon. In the case of copper-acetyl-acetic ether, prepared by the action of an ammoniacal solution of copper sulphate on acetylacetic ether, the author establishes the formula as  $CH_3CO\text{-}\underset{COOC_2H_5}{\underset{|}{CH}}\text{—}Cu\text{—}\underset{COOC_2H_5}{\underset{|}{CH}}\text{-}COCH_3$, in which the carbon atoms of the two groups are linked directly by copper. Nickel, cobalt, magnesium, aluminum and mercury compounds were also prepared.—*Liebig's Ann.*, clxxxviii, 269, Aug., 1877. G. F. B.

5. *On Phyllic acid, extracted from leaves.*—BOUGAREL has succeeded in isolating from the leaves of the cherry-laurel, a new acid to which he gives the name phyllic acid. The leaves are extracted with boiling alcohol, the extract left on distilling off the alcohol, is treated with ether, the solution is clarified with animal charcoal, the ether distilled off, and the amorphous grains dissolved in dilute potash solution and several times crystallized. On re-dissolving and adding an acid, phyllic acid is precipitated as a resinous mass. It is soluble in alcohol, ether, chloroform, CS_2, essential oils and fats, but insoluble in water. Several times precipitated from ether, it forms a fine powder without odor or taste, having a density of 1·014, rotating in alcoholic solution, $\alpha_j = +28$, melting at 170°, and decomposing at 200°. Analysis of the potassium salt fixed the molecular weight at 624; and ultimate analysis, conse-

quently, the formula $C_{72}H_{64}O_{16}$, which the author regards as provisional only. The sodium and ammonium salts are well crystallized. The acid has also been obtained from the leaves of the quince, apple, peach, almond, sycamore, lilac and jaborandi.—*Bull. Soc. Ch.*, II, xxvii, 148, Sept., 1877. G. F. B.

6. *On the Constitution of Euxanthon.*—SALZMANN and WICHELHAUS have experimented to determine the constitution of euxanthon, prepared from euxanthic acid (which exists in the form of magnesium salt in the yellow coloring matter called purree or indian yellow) by solution in concentrated sulphuric acid and precipitation by water. It has the composition $C_{13}H_8O_4$. Its vapor passed over zinc powder in a current of hydrogen gave the product $C_{13}H_8O$. This, oxidized with nitric acid or permanganate gave $C_{13}H_8O_2$; treated with fuming nitric acid, gave a nitro-product $C_{13}H_6(NO_2)_2O_2$; and suspended in water containing bromine formed two bromine derivatives $C_{13}H_2Br_6O$ and $C_{13}HBr_7O$; euxanthon itself heated with acetyl chloride to 100° gave diacetyl-euxanthon, $C_{13}H_6(C_2H_3O)_2O_4$. From these reactions, taken in connection with the fact that Baeyer obtained a hydroquinone-like body on reduction with sodium amalgam, the author regards euxanthon as a carbonein of hydroquinone  $CO\begin{matrix} C_6H_3 \diagdown & OH \\ & >O \\ C_6H_3 \diagup & OH \end{matrix}$, the reduction product with zinc being carbodiphenylene $CO\begin{matrix} C_6H_4 \\ C_6H_4 \end{matrix}>$, giving on oxidation carbodiphenylene oxide  $CO\begin{matrix} C_6H_4 \\ C_6H_4 \end{matrix}>O$.—*Ber. Berl. Chem. Ges.*, x, 1397, Oct., 1877. G. F. B.

7. *Density of Vapors.*—One of the most important of the recent additions to chemical methods is that of Victor Meyer for determining the density of the vapor of substances which have a high boiling point. As in the method of Gay-Lussac or in the modification of that method as employed by Hoffman, a given weight of the substance used is converted completely into vapor and the volume of this vapor measured under determinate conditions. An amount of the substance not exceeding seven or eight centigrams but varying naturally with the density of the vapor to be determined is weighed out in a small glass tube of such size and shape that it can easily be passed through the curved neck into a glass bulb holding about twenty-five cubic centimeters. The glass tube at the end of which the bulb is blown is bent into a U shape and cut off so that its open mouth is on a level with a capillary opening on the top of the bulb, and the little apparatus is suspended by a wire holder so that these openings are always uppermost. The glass having been weighed to decigrams and the material introduced, the interior is filled at 100° C. with Wood's fusible alloy which melts at 70° C., the capillary opening at the top of the bulb allowing the air to escape while the melted metal is poured in through the open mouth. As soon as the bulb is filled this capillary opening is closed by a blow-pipe; and as soon as, after exposure in a steam bath, the excess of metal has overflowed, the

apparatus is wiped and again weighed, but as before, only to decigrams. The apparatus is now immersed in the vapor of boiling sulphur, which, according to the experiments of Regnault has a constant temperature of 442·2° when the barometer stands at 723·5 mm.* The substance passes into vapor and a considerable portion of the alloy overflows and the tension of the vapor thus formed is evidently measured by the height of the barometer column at the time, plus the equivalent in mercury of the height of the column of melted metal which fills the neck of the apparatus above the level of the metal in the bulb. The last is easily measured with a millimeter scale if at the instant of lifting the apparatus from the sulphur bath the level of the metal is marked on the bulb, which may be easily done with melted sealing wax, using a heated glass rod as a pen. When now the apparatus has partially cooled and the adhering particles of metal have been removed, it is weighed for the third time and from the three weights we easily ascertain what quantity of metal has overflowed in the sulphur bath. This amount is obviously a measure of the volume of the vapor formed. It is not, however, a direct measure, for the overflow is caused not only by the formation of the vapor, but also by the expansion of the alloy, while, on the other hand, it is diminished by the expansion of the glass. Before, therefore, the data thus obtained could be used in calculating the density of a vapor it was necessary to determine the density of the alloy at the boiling point of sulphur, also the apparent expansion of the alloy in the ordinary German glass when heated from 100° to the same temperature. This Victor Meyer has done, and according to his determinations the apparent expansion of the alloy was, on the average, 0·036, and at 444° one gram had the volume of 0·1092 c. c., so that its density was about two-thirds of that of mercury. From these values he deduces the following formula for the calculation of the vapor density from such observations as we have described:

$$\text{Density (referred to air as unity)} = \frac{w\ 14146000\dagger}{(W-0{\cdot}036\ W')(H+\frac{2}{3}h)};$$

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* This is the mean height of the barometer at Zurich where Meyer's determinations were made. At the mean level of the sea with the mean height 760 mm. the boiling point is more nearly 447·7°.

† At the sea level when the barometer stands at 760 mm. this constant becomes 14216000. Either value is easily deduced.

The amount of substance taken gives at 444·2° a definite volume of vapor at a measured tension. Let that volume in cubic centimeters be represented by v and the tension in millimeters by H'. The density of the vapor is equal to its weight divided by the weight of the same volume of air at the same temperature and tension, or $\delta = \frac{w}{w'}$ and as is well known,

$$w' = 0{\cdot}001293\,\frac{1}{(v1+0{\cdot}003665{\cdot}444^{\circ}{\cdot}2)} - \frac{H'}{760}.$$

But in the process we are considering the volume of the vapor is evidently equal to the volume of the overflow at 444·2° less that of the overflow which would have resulted from the expansion of the metal and glass alone, or $V = 0{\cdot}1092\,(W-0{\cdot}036\,W')$ and as we have seen, $H' = H + \frac{2}{3}h$. Making now the substitutions and combining the numerical values we obtain the expression given above.

here w is the weight of the substance used, W′ the weight of alloy which filled the bulb at 100°, and W the weight which overflowed in the sulphur bath; also H the height of the barometer and h the difference of level of the alloy in the bulb and neck of the apparatus at the moment it was withdrawn from the bath.

Wood's fusible alloy is exceedingly well adapted to the use to which it has been so beautifully applied by Victor Meyer. As prepared and sold by Dr. Schuchardt of Görlitz it appears to have a very constant composition and equally constant physical qualities. Moreover, it is but slightly acted on by boiling sulphur and can readily be recovered from the sulphur bath into which it overflows. It can then be easily cleaned and used over again repeatedly. But for these and other details we would refer to the very full description of the process which has recently appeared in Fresenius' Zeitschrift für Analytische Chemie, xvi, 482. Of course the method has a limited application and can not be used with any substance which would act chemically upon the alloy. Still it has already very considerably extended our knowledge of the vapor densities of the less volatile organic products, and for such substances it is both more easy of application and more accurate than the only comparable method, that of Dumas as modified by Deville and Troost. We add two examples for illustrations.

Anthrachinon.

Substance used	w	= 0·0652 grm.
Metal used	W′	= 264·4 “
“ which overflowed	W	= 179·6 “
Barometer height	H	= 728·5 mm.
Difference of level	h	= 33· “
Resulting density		7·22
Theory for $C_{14}H_8O_2$		7·19
Found by Gräbe with the process of Deville and Troost		7·35

Paradibrombenzol.

Substance used	w	= 0·0772 grm.
Metal used	W′	= 261·5 “
“ which overflowed	W	= 187·4 “
Barometer height	H	= 728·5 mm.
Difference of level		38 “
Resulting density		8·14
Theory for $C_6H_4Br_2$		8·15

J. P. C., JR.

8. *New Results in Physics.*—(1.) A. F. BERGGREN concludes that the chlorides of the alkalies and alkaline earths possess greater electrical conducting power than the soluble sulphates of the same bases.—*Ann. der Physik und Chemie*, new series, vol. i, p. 499.

(2.) SILOW has undertaken an investigation of weak magnetic substances. His method consists in observing the deviation of an astatic system of needles, produced by appending to it a cylindrical vessel containing the magnetic substance under consideration. He discusses the method by the aid of the theory of potentials and obtains for an aqueous solution of chloride of iron of density 1·475 a magnetizing constant of $K = 0{\cdot}0000815$.—*Ib.*, p. 481.

(3.) HANKEL discusses the results of previous experiments upon the electrical effect of light rays upon metal plates, immersed in fluids, and adds some experiments of his own which show that the difference of potential of certain metal plates immersed in fluids is sensibly altered by light; and that in certain cases this effect is opposite to that caused by the heat rays.—*Ib.*, p. 402.

(4.) CLAUSIUS shows that if there are a number of conducting bodies C_1, C_2, C_3, etc. which influence each other and if these bodies are first charged with the quantities of electricities Q_1, Q_2, Q_3 etc. giving the potentials V_1, V_2, V_3 etc., and afterwards charged with the quantities $\mathfrak{Q}_1$, $\mathfrak{Q}_2$, $\mathfrak{Q}_3$; with the potentials $\mathfrak{V}_1$, $\mathfrak{V}_2$, $\mathfrak{V}_3$; the equation $\Sigma V\mathfrak{Q} = \Sigma\mathfrak{V}Q$ results.—*Ib.*, p. 493.

(5.) HERMAN HERWIG collects the facts in regard to the different mechanical actions of positive and negative electrical poles; joins to these some observations of his own in regard to the behavior of flames placed between their poles, and discusses the generality of these phenomena together with their bearing upon the two-fluid theory of electricity.—*Ib.*, p. 516.

(6.) According to an investigation of W. von MUNCHHAUSEN carried on in the laboratory of A. Wullner, the specific heat of water at $t°$ is represented by the expression $K = 1 + 0{\cdot}000302t$.—*Ib.*, p. 592.

J. T.

II. GEOLOGY AND MINERALOGY.

1. *China*, by FERDINAND FREIHERRN VON RICHTHOFEN. 1st vol. Introductory Part. 758 pp. roy. 8vo, with 11 charts (several colored), and 29 wood cuts. Berlin, 1877.*—Baron von Richthofen left Europe on his first visit to China in 1860, under the auspices of the Prussian Government. Only a few prominent points in China were visited, the interior of the country not being then accessible, owing to the Taiping rebellion. He also went to Siam, Formosa, the Philippines, Celebes and Java. Japan was not at the time open to foreigners.

The year 1867 and part of 1868 were spent in California, in connection with the Geological Survey of that State under J. D. Whitney; and a volume treating learnedly of the Natural System of volcanic rocks, and describing those of Western North America was one result of his labors.

In July, 1868, he left for a second visit to China. He was there the larger part of four years, and made seven long journeys over the country, and among the islands and peninsulas of the coast. He visited many of the Provinces, reaching, at his farthest point west, the center of the Province of Sz-tschwan, over 900 miles west of Shanghai, and to the north, the borders of Mongolia, northwest of Pekin. During a portion of the years 1870, 1871 (from August, 1870, to the spring of 1871), he was in Japan.

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* *China.* Ergebnisse eigener Reisen und darauf gegründeter Studien; von FERDINAND FREIHERRN VON RICHTHOFEN. Erster Band. Einleitender Theil. Berlin, 1877. (Verlag von Dietrich Reimer.)

The work, of which the 1st volume, out of the four to be published, has recently been issued, will embrace the results of his observations and studies with reference to the topography of China, its geography, climate, density of population in different parts of its history, its productions and their mercantile importance, its geology, paleontology, etc. Besides the account of China, the work will contain a sketch of the author's observations also in Japan, Formosa, Manilla, Java and Siam; and, in conclusion, a discussion of some problems connected with the earth's general features and history, as illustrated by the special facts observed.

The fourth volume, on the Paleontology, will be prepared by prominent specialists, among them, Dr. Kayser of Berlin, Prof. Schenk of Leipzic and Dr. Schwager of Munich. There will also be an atlas of forty-four charts, besides numerous cuts and maps in the text. The atlas will contain twenty-eight special charts on the scale of 1: 750,000; a general chart of China, on that of 1: 3,000,000; and other charts to illustrate the geology, geography of products, density and movements of population, etc., in China; also, a general chart and several special charts of Japan. The volume issued is princely in its style of publication; and it manifests, besides, that the work will be thorough in its discussion of the subjects taken up.

The first volume commences with a survey of the general topography of China and Central Asia. It next treats of the löss-formation of Northern China—its features, structure and origin, and its relations to the salt steppes of Central Asia and the löss-deposits of other countries. The mountain-systems of Central Asia are then described, and with this subject Part I closes. Part II consists of a history of geographical knowledge with regard to China, and treats of ancient Chinese geographies and charts, Chinese geographical learning, and the development, during the different periods of Chinese history, of the intercourse of the people with the people of Southern and Western Asia, and, after the arrival of the Portuguese, in 1817, with the nations of Europe.

The account of the *löss-formation of Northern China* is of special interest, because of its wide distribution and its connection with the social condition and welfare of the people. Baron von Richthofen observes that west of the alluvial plain of the sea-border —which plain in the vicinity of Pekin extends 175 English miles west from the Petschili gulf—there is a terrace of löss thirty to eighty meters in height. Continuing west, there is, next, a mountainous region on the east border of the Province of Shansi, and then succeeds a plateau largely covered with löss, which is 600 to 1,000 meters above the sea-level. Again, farther west, after passing a mountain range, there is a second plateau, 1,500 to 1,800 meters above the sea-level, which is covered in great part with löss. The river Fönn-ho (a stream flowing southward into the Hoang-ho, through the center of the Province of Shansi), occupies a deep channel cut through it along its western border. West of this plateau there is another mountainous region, in which flows north and south, for 300 miles, the Hoang-ho or Yellow River. Beyond, through the Provinces of Shensi and Kansu, the löss is widely spread; and, on the authority of the missionaries and the Chinese, it continues in the valleys to the most western sources of the affluents of the Hoang-ho, over 900 miles from the coast. The löss spreads northward along the plains or valleys into Mongolia. Southward, it occupies basins in the broad valley of the Wei, the largest tributary of the Hoang-ho; and it also occurs in the valley of the Han. It is found also farther east over parts of the low near Nanking, Tung-ting Lake, and Po-yang Lake, which are its lands of Honan and Shantung. South of Honan it exists in isolated areas along parts of the valley of the Yang-tsze River, as extreme southern positions. Its greatest areas are in the region of the Hoang-ho and its tributaries, in some portions of which it has a thickness of several hundred feet—even 2,000 to 2,500, according to Baron von Richthofen.

The material of the löss, like that along the Rhine, is a brownish-yellow earth (whence the name "Yellow River," given to the Hoang-ho), very porous, exceedingly fine in grain, and friable when dry; and affording on chemical analysis, more or less carbonate of lime. It often contains, at different levels, calcareous concretions (Löss-männchen); and also in some places the shells of land-snails and bones of terrestrial mammals, but never, according to the author, shells of fresh-water snails. Vegetable remains also occur in it. From top to bottom it is penetrated by very small tubular passages, which are like those that are now in many places left by the rootlets of grasses and other small plants, after their decay; and these are set down as evidence that the whole mass of the löss has been successively penetrated by the rootlets of growing plants. The löss deposits have very generally, as on the Rhine, a vertical cleavage structure leading to its becoming eroded vertically, and is without the thin horizontal lamination or planes of bedding of ordinary alluvium. There are often, however, at intervals usually of more than fifty feet (but varying from a few feet to more than a hundred), horizontal divisional planes which are usually connected with planes of concretions. In consequence of these structural peculiarities, the löss fronts the valleys with high vertical walls, in which are occasional horizontal terrace-like shelves. It becomes reduced by intersecting streams or streamlets, and the rills from the heavy rains, to regions of deep and narrow labyrinthine passage-ways, groups of lofty obelisks, castles, clustered towers. Instructive views of its scenery are given in the volume.

Baron von Richthofen discusses the theories as to the origin of the löss, and adopts that which he had advocated in his memoirs on the Provinces of Honan and Shansi, published at Shanghai in 1870. He objects, with reason, to the theory of marine submergence, advocated by T. W. Kingsmill, Esq., in the Quarterly Journal of the Geological Society for 1871 (p. 376,) on the ground that the shells, bones and vegetation are all terrestrial; that there are no marine relics of any kind in the deposits; and states that it would require an oscillation of level of several thousand feet, which would give a chance for the introduction over the area of China, within comparatively recent times, of all kinds of marine life. He rejects also the view that the löss is of freshwater origin deposited from the waters of vast lakes that formerly covered a large part of the country—the opinion brought out by Raphael Pumpelly in his valuable "Geological Researches in China, Mongolia and Japan," published in 1866;* urging that the shells are not transported shells, but instead occur where they were left by their animals; that there are no freshwater species; that the indications of vegetation (mentioned above) are so extensively distributed through the löss, that the plants must have grown abundantly over its surface as the accumulation went forward instead of being a deposit by transporting waters; that the bones of mammals indicate also that they have not been transported. He says also that there is no evidence of glacial origin, no moraines or other marks of glaciers having been observed in any part of the country.

Baron von Richthofen holds that the löss formation is a subaerial accumulation, due to the drifting action of the winds; to transportation by rivulets from the hills immediately adjoining each löss basin; and to the mineral material left over the basin by the growing grasses and other plants. The first and the last of these causes are made the most effectual. The degradation of the rocks of the neighboring hills by decomposition and alternate changes of temperature, produces the loose grains for transportation. The plants covering the great plains served to stop the wind-drifted earth, and so keep the accumulation ever in progress. He observes that the true löss is made over a dry surface and he calls it *land-löss.* But the löss basins have generally had a lake at center; and about the lake the deposit is thin-laminated or stratified; and this he calls *lake-löss.* The lakes had formerly greater width than now; and in the valley of the Wei where the true löss is extensive, he has seen it overlying the laminated lake-löss. About the dried-up basins, under the present dry climate, salt efflorescences are common.

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* Mr. Pumpelly's Memoir was published in a quarto of 144 pages, with maps, by the Smithsonian Institution, as No. 202 of the Smithsonian Contributions to Knowledge, Washington, D. C., October, 1866. The author visited the region northwest of Pekin on the borders of Mongolia. His descriptions of the features of the löss regions are like those of von Richthofen. He says, after alluding to its vertical cleavage: "The country is often cut up by gullies thirty to seventy feet deep, and from ten to twenty feet wide, with vertical walls. In these channels wagon-roads run for many miles without rising to the plain. In the valley between the Kwantung (pu) and the Yangkau defile, I crossed a gully forty or fifty feet deep and not more than four feet wide, having the same breadth all the way down, and following, with these dimensions, a tortuous course for more than a mile." "Wherever a cliff of this deposit presents itself, the beginning of this action is visible. The surface drainage of a small neighboring area of the plain being concentrated toward one point on the edge of the cliff, cuts, in its fall, a channel from top to bottom, and this with each succeeding rain works its way backward toward the mountain. As the erosion progresses, the sides of the gullies offer new starting points for tributary ravines."

From all the facts he concludes that the löss-basins were originally sites of salt lakes; that the land had less height in the interior to the northward than now, as shown by the succession of löss basins going west, and that the basins had consequently very great extent; that the climate was so dry that the evaporation exceeded the fall of water, and consequently the streams were very feeble, or dried up, and that this was another occasion for great undrained basins; that the true löss was formed about the dry borders of the basins by the methods above mentioned, and gradually spread inward covering the lake-löss as the water of the basin diminished, so giving the upper surface of the deposit a slight pitch inward, which feature he states (as also Pumpelly) is common; that the condition of Northern China, at the time, was much like the present state of the salt-steppes of Central Asia; and that the löss-making era was brought to an end by a change of climate in which great rains changed the rivers to floods, which led to their cutting channels through the basins and opening up the present system of drainage. Thus the Hoang-ho came into its modern existence. The reference to a less height formerly over the interior than now would seem to imply that this drainage result was promoted also by an elevation to the present level. The löss where it adjoins the hills often contains alternating beds of pebbles and earth; and this is attributed to rivulets from these hills. The salt-steppes of Central Asia are particularly described in order to illustrate the views advanced.

Mr. T. W. Kingsmill's article, referred to above, was written as a criticism of Baron von Richthofen's views; and it is of interest here to have his arguments. The most important are these: that the disintegration going on over the hills is a very inadequate source of material for such great and thick deposits, and the winds an insufficient means of transportation; that the plants could furnish to the mineral accumulations only what they took from it, and hence would add nothing; that the löss is so easy of removal that, if terrestrial in origin, it would have been more or less carried off, and hence so thick accumulations could not have been made. Mr. Pumpelly's memoir appeared in advance of Baron von Richthofen's. He argues (from facts observed northwest of Pekin and about Kalgan) for the freshwater and lacustrine origin of the löss from the presence of shells in the deposits (at Té Hai); from the uniform constitution and fineness of the löss, this "proving that it has not come from what were the neighboring shores, but that it was brought into the lakes by one or more large rivers, which must have drained an area of great extent." J. D. D.

2. *International Geological Congress.*—The number of this Journal for December of 1876 contains the announcement of the

appointment of a Committee, by the American Association for the Advancement of Science, to take action with reference to holding an International Geological Congress at Paris, during the Paris Exposition of 1878; and also the resolution adopted, and a statement of the objects to be accomplished; the facts being derived from a Circular issued by the Committee, of which Prof. James Hall is Chairman.

At the recent meeting of the Association, at Nashville, a report on the subject was presented by the Secretary of the Committee, Dr. T. Sterry Hunt. According to it, the circular was sent to learned societies over the world, and has everywhere called forth gratifying responses. The Geological Society of France has expressed its hearty coöperation; and English, Russian, Swedish, Norwegian, Austrian, Spanish and Italian geological societies and geologists have given their approbation, and assurances that they will further the objects of the Congress. Prof. Capellini has, in this connection, called attention to the fact that in 1874 he laid the project of a similar International Geological Congress, to be held in Italy, before the Italian Minister of Agriculture, Industry and Commerce. Germany has declined to take any part in the French International Exhibition, but this may not prevent her geologists from joining in the proposed Congress. The precise date of the Congress has not yet been fixed. The Secretary of the Committee is now in correspondence with the Secretary of the Geological Society of France upon this point, and believes that a time convenient to all will be agreed upon.

The Report also embodied a resolution of the Standing Committee of the Association recommending that the Presidents, for the time being, of the Geological Societies of France, London, Edinburgh, Dublin, Berlin, Belgium, Italy, Spain, Portugal, and the Imperial Geological Institute of Vienna, be invited to form part of the Commission.

After the presentation of the report to the American Association, the Secretary received official notice that the Geological Society of France, had, in coöperation with the above plan, appointed in Paris a local committee of organization for the proposed Congress, constituted as follows: Hébert, President; Tournouer and Albert Gaudry, Vice-presidents; Bioche, Treasurer; Jannetaz, Secretary-general; Delaire, Sauvage, Brocchi and Vélain, Secretaries; with the following: Belgrand Bureau, de Chancourtois, G. Cotteau, Damour, Daubrée, Delafosse, Delesse, Descloizeaux, Desnoyers, Fouqué, Gervais, Gruner, De Lapparent, Mallard, Milne-Edwards, Pellat, Marquis de Roys and L. Vaillant, members of the Committee.

A circular issued by this Committee, bearing date July 31, invites all those interested in geological, mineralogical and paleontological studies, to take part in the approaching Congress, and to subscribe the sum of *twelve francs* each, which will give a card of admission to the Congress, and right to all the publications thereof. All those who intend to be present are at the same time invited to send, as soon as possible, a list of the questions which seem to them worthy of general discussion, as well as of the communications which they intend to make touching these questions. They are also invited to indicate what time appears to them most convenient for the meeting of the Congress.

As regards an International Geological Exhibition, the Paris Committee of organization state that the difficulty of finding a suitable locality seems to them an obstacle in the way of realizing this part of the programme. They hope however that there will be many special collections sent, and beg the exhibitors of such to give the committee due notice of these, in order that a special catalogue of them may be prepared.

The circular issued by the Committee of the American Association did not contemplate, as Dr. Hunt states, the holding of an International Geological Exhibition apart from the Universal Exhibition, but, in the language of that circular, *the making as complete as possible the geological department* of the Universal Exhibition. It is certain that, as at all previous similar exhibitions, the different nations will contribute more or less of geological material; and it was conceived that such collections, extended and systematized in accordance with the plan set forth in the circular, would, while forming a part of the Universal Exhibition, without farther cost meet all the requirements of an International Geological Exhibition. To the accomplishment of this end it will only be necessary for the exhibitors of all nations to send a list of their geological contributions to the local Committee of organization at Paris.

All correspondence relating to the Congress should be addressed to Dr. Jannetaz, Sécretaire-général, Rue des Grands Augustins, 7, Paris, France, and all moneys sent to Dr. Bioche at the same address.

3. *Palæontology of New York. Illustrations of Devonian Fossils: Gasteropoda, Pteropoda, Cephalopoda, Crustacea and Corals, of the Upper Helderberg, Hamilton and Chemung Groups;* by JAMES HALL. Over 140 quarto plates. Albany, 1876. Published in advance of the Palæontology of New York, by authority of the Legislature of the State of New York.—Volume IV of Professor Hall's great work on the Paleontology of New York was published in 1867, and contained descriptions and figures of the fossil Brachiopods of the Upper Helderberg, Hamilton, Portage and Chemung groups, illustrated by about seventy plates. Since its publication, as the Preface to this new volume states, the drawings for the plates of the remaining part of the Devonian fossils have been going forward, while, through duties connected with the care of the Museum, in connection with impaired health. the descriptions still remain incomplete. In 1875, *eighty* plates of the Lamellibranchs had been drawn and lithographed, and the drawings of the greater part of the Gasteropods, Pteropods, Cephalopods and Crustacea, now issued in this new volume, had

been finished, while those of the Corals were in progress. During that year the Legislature of the State authorized the publication, by the albertype process, of a hundred copies of each of one hundred of the plates, and, the following year, of thirty additional plates. Through this means the new volume of plates, with the explanatory pages of text, has been issued. All the plates it contains were photographed from excellent original drawings, excepting part of those of the Corals which are direct from the specimens. The most of the drawings were made under the supervision of Mr. R. P. Whitfield, and many of those of the Gasteropoda and Cephalopoda with his aid.

The plates form a beautiful volume, and, with the explanations accompanying each, they constitute a work which will be of great immediate service to the science even without the promised volume of text. The albertypes, by E. Bierstadt, are admirable, and those direct from the specimens of corals are unusually fine. In preparing the explanations of the plates of Corals, Dr. Rominger, whose labors and publications in connection with the Michigan Geolological Survey have made him an authority in that department, was conferred with, in order to avoid any duplication of species.

Professor Hall states that to complete the Devonian Cephalopoda, the number of plates—here forty—will have to be doubled, the plates of the Crustacea will need some additions, and those of the Corals, here over forty, will have to be greatly increased in number. Prof. Hall's labors have been of vast service to American Paleontology, and of great honor to the State under whose auspices his Reports have been published, and it is to be hoped that they will not be brought to a close before every fossil species of the New York rocks has been illustrated and described.

4. *Twenty-eighth Annual Report of the New York State Museum of Natural History, by the Regents of the University of the State of New York.* 100 pages, 8vo, with 34 plates. Transmitted to the Legislature, March 30, 1875. Albany, 1875.—This Report, whose contents are mentioned on page 432, is one of special paleontological value. The chief article is by Prof. Hall, and consists of plates and their explanations illustrating "the fauna of the Niagara Group in Central Indiana." The number of plates is thirty-two. The figures include species of fossil Sponges, Corals, Crinoids, Bryozoans, Brachiopods, Gasteropods and Trilobites, many among them new.

The first two plates illustrate new species of Fungi, described by the State Botanist, C. H. Peck. The new Trenton fossils described by C. D. Walcott are of the genera *Conularia*, *Conchopeltis* (new patelliform shell), *Bathyurus* and *Asaphus*.

5. *Notes on some new sections of Trilobites from the Trenton Limestone and descriptions of new species of fossils*, by C. D. WALCOTT. 22 pp. 8vo, with one plate. Published in advance of the Rep. N. Y. State Museum, Sept. 20, 1877.—In this paper Mr. Walcott gives an account of the discovery of articulated append-

ages connected with the mouth of Trilobites, derived from sections of Trenton specimens of *Calymene senaria*, *Ceraurus pleurexanthemus* and *Acidaspis Trentonensis*. Only two sections are figured and their precise position across the head is not stated. More sections are needed before the facts observed can be satisfactorily interpreted.

Mr. Walcott has also observed in sections of the body of a *Ceraurus pleurexanthemus* what he regards as remains of the ova of the animal, similar to those described by Barrande as occurring in *Barrandia crassa*. The space between the dorsal shell and the ventral membrane, and the cavity of the head in part, were found to be filled with the ovoidal bodies, over 200 of which were counted in one section. The diameters were one-quarter and one-half of a millimeter. The eggs of Crustaceans are so destructible that the question naturally arises whether the ovoidal bodies are not of concretionary origin.

6. *Large Bowlders in New Hampshire.*—One of the largest of bowlders has been recently found by Governor Prescott upon the land of E. H. Chase in the west edge of Nottingham, New Hampshire, at the base of Pawtuccaway Mountain. It measures 62 feet long, 40 wide and is at least 50 feet high. The cubic contents are about 70,000 feet, giving for the weight nearly 6,000 tons. Close by this are two others, each including nearly 50,000 cubic feet; and within the distance of one-fourth of a mile are nine more of about the same size.

The largest bowlder in Vermont is called the Green Mountain Giant, lying on a hill in Whitingham; it contains 40,000 cubic feet.—*Daily Monitor, Concord, New Hampshire*, Oct. 15.

7. *Application of Organic Acids to the Examination of Minerals;* by H. CARRINGTON BOLTON, Ph.D. 36 pp. 8vo, with one plate. New York Acad. Sci., i, 1877.—Professor Bolton presents in this memoir the results of a long investigation with regard to the action of citric, tartaric, and oxalic acids on minerals, and their use in the determination of species; and also of a few trials with malic, formic, acetic, benzoic, pyrogallic, and picric acids. The minerals were subjected to the acids in powder, the solid acids having been made into saturated solutions.

From a table in the concluding part of the memoir, we take the following reactions of citric acid. CO_2 is given off when the cold acid acts on the mineral carbonates, excepting magnesite and siderite which require heat. CO_2 is also given off, when acting with the hot acid on wad, hausmannite, manganite, and psilomelane. H_2S is liberated when acting with the cold acid on stibnite, galenite, sphalerite, pyrrhotite, and, with the hot acid on bornite and bournonite as well as the preceding. A jelly is formed when the hot acid acts on willemite, datolite, pectolite, calamine, natrolite; and non-gelatinous silica, when the same acts on wollastonite, chrysolite, chondrodite, chrysocolla, prehnite, apophyllite, rhodonite, analcite, chabazite, stilbite, serpentine, retinalite, deweylite. The following minerals are decomposed by boiling with citric acid and KNO_3: argentite, chalcocite, pyrite, marcasite, niccolite, smaltite, chalcopyrite, ullmannite, arsenopyrite, tetrahedrite, uraninite, and also the species above enumerated as decomposed with the H_2S. The following are decomposed by boiling with citric acid and NH_4Fl: olivine, wernerite, orthoclase, albite, labradorite, augite, diopside, hornblende, cyanite, talc, spodumene, almandine garnet, epidote, and also the above-enumerated species which yield silica.

Professor Bolton remarks that solid citric (or tartaric) acid is far more convenient than hydrochloric for the traveling mineralogist; and also that potassium nitrite, KNO_2, should be added to the usual list of blowpipe reagents; for it yields with citric acid, nitric acid, and it affords a convenient means of carrying this reagent. We refer to the memoir for special details with reference to the several mineral species studied by Professor Bolton.

8. *Note on Uranium minerals in North Carolina;* by W. C. KERR, State Geologist. (Communicated.)—Besides the samarskite of the Wiseman Mica Mine in Mitchell County, with the associated hatchettolite of Dr. Smith, the minute crystals of microlite found in several mines, and some stains and incrustations of uranium compounds, a new locality, the Flat Rock mine, recently visited, has yielded the following, in immediate association, viz: *Uraninite*, *Gummite*, *Uraconite*, and, as incrustations on the outside of the latter, and of the fragments of rock adjacent, *Torbernite* and *Autunite.* These minerals occur only in one part of the mica-bearing portion of a very large granite vein, and are found in irregular nodules and rounded masses, some with a nucleus of uraninite of one-half to three-fourth inch, enveloped with a heavy layer of gummite, outside of which is a pale yellow earthy coating from an eighth to a fourth of an inch thick, which is uranochre, or uraconite. One lump, the largest, weighs just a pound, and in all I obtained between three and four pounds. The quantity of pitchblende remaining unaltered is very small and by far the greater part of the mass of the nodules, probably nine-tenths, is gummite; and the smaller ones are nearly or entirely changed to uraconite.

I have recently obtained specimens, one pound in weight, of samarskite from a new locality, viz: Grassy Creek Mine, in Mitchell County. Previously this mineral had been found chiefly, I believe only, at the Wiseman Mine.

A notable fact in connection with the occurrence of these uranium compounds is their association with a characteristic pinkish feldspar, which suggests the inquiry whether there may not be another mineral of this group not yet determined; and this is rendered the more probable by the presence, in the Wiseman Mine at least, of a thin earthy coating on the cleavage surface of the feldspar of a pronounced pinkish color. Professor Julien has some of this in hand for determination, as soon as he can isolate enough for that purpose.

III. BOTANY AND ZOOLOGY.

1. *The Wild Flowers of America;* illustrated by ISAAC SPRAGUE. Text by GEORGE L. GOODALE, M.D., Assistant Professor of Vegetable Physiology and Instructor in Botany in Harvard University. Part II. Boston, H. O. Houghton & Co.—No color-printing of flowers in this country had at all equalled that of the first part of this beautiful work. Yet the long interval between its appearance and that of the present fasciculus need not be regretted, since it has enabled the lithographers to do still better justice to Mr. Sprague's drawings, and to the beautiful subjects of them. Those unacquainted with the perfection to which the art has been brought will find it hard to believe that these plates have not been painted by the hand, and by no ordinary hand. The text is well done, especially where, as in the Iris or Blue Flag, and the Arrow-leaved Violet, the subject allowed of interesting treatment. The flowers not having been selected for other than pictorial representation, it sometimes happens that there is little to say about them. But when the nomenclature has been brought up to date so closely as to adopt the genus *Steironema*, it might have been mentioned that the cogent reason for the rehabilitation of Rafinesque's genus was not the sterile filaments, which were known from the first and suggested the name, but the involution of the petals in the bud around the filaments, separately enwrapping each, which was a new discovery. In the letter-press accompanying the very pretty plate of *Viola sagittata* (which is well set off with a tuft of sedge behind it), the method of the discharge of the seeds is clearly explained, and the nearly similar mode in *Hamamelis* is incidentally alluded to as if it were a recent discovery of the persons mentioned. Far earlier dates are referred to in this Journal for Feb., 1873, with a reference to the amusing muddle of the subject into which an English scientific periodical was led. Eastern flowers have served hitherto; but in the present fasciculus the ultra-Mississippian *Rudbeckia* (*Lepachys*) *columnaris* figures, and to great advantage, especially the two-colored variety. The velvety red-brown bases of the drooping yellow rays is admirably rendered. A. G.

2. *Cleistogamy in Impatiens.*—When M. A. Loche, a year ago, read a paper before the Botanical Society of France (printed in its Bulletin, xxiii, 367), in which he described the production of fruit and seeds in *Impatiens Nolitangere*, apparently without participation of the male sex, and when two learned botanists present suggested that this might be a case of clandestine flowering or close-fertilizing in the bud, as in *Lamium* and in *Viola*, it is remarkable that no one called attention to the fact that this case of Impatiens was described and properly explained by Adrien de Jussieu thirty-three years ago, in a classical work, and the observation credited to Weddell, the excellent botanist whom we have since lost. A. G.

3. *Catalogus Plantarum in Nova Cæsarea Repertarum.*—This is the title on the cover. The title page, all English, is "Catalogue of Plants growing without cultivation in the State of New Jersey, with a specific description of all the species of Violet found therein, Directions for Collecting, Drying, Labeling and Preserving Botanical Specimens, and a description of suitable apparatus therefor; with suggestions to Teachers prosecuting the study of Botany; to which is added Directions for commencing the study of Botany; also a Directory of living Botanists of North America and the West Indies. By Oliver R. Willis, Ph.D., Instructor of Natural Science in the Alexander Institute. Revised and enlarged edition, (A. S. Barnes & Co.: New York, &c." 8vo, pp. 88.) This full title leaves no need and little room for any particular account of this compendious volume. It lacks only a date, which we may put at 1877, and it has an Index. The preface to the first edition bears the date 1874. We gave a notice of the original edition at the time; the present edition is much enlarged and improved. The author, supposing that his publication "will fall into the hands of men who can form a just estimate of the difficulties and labor incident to the preparation of a work like this," adds that, "consequently I expect to be judged with lenity and criticised with charity." We see no good reason for disappointing his expectations. We will add—since the title page does not mention it—that, while the catalogue stops with the *Lycopodiacea*, it is supplemented by one of marine Algæ, by Samuel Ashmead, and that there is a monograph of the forms or varieties of the fruit of one of the States' staple products, the cranberry. New Jersey has a rich flora, as is well known. This catalogue enumerates 1,603 species of Phænogamous plants, and states that there are fifty-seven first class and thirty-seven second class trees. But this includes introduced species. A. G.

4. SIR JOSEPH DALTON HOOKER reached his home at Kew on the 19th of October, after an unusually long voyage of almost a fortnight. In his rapid reconnoissance of the botanical features of the United States he traveled over between nine and ten thousand miles of American territory, ascended some of the highest mountains, and botanized with a vigor and industry which he could hardly have excelled in his youthful days. The time—all too short—was almost wholly given to the wide regions between the Mississippi and the Pacific, for which, through the connection with Dr. Hayden's Survey, and with his personal assistance and companionship (as well as that of a fellow botanist of long experience), unusual facilities were afforded. He promises to renew his visit as soon as possible, and then to endeavor to see something of the Atlantic States (its institutions as well as its natural productions), and also of New Mexico, Arizona and Southern California, which are now becoming readily and promptly accessible to the rapid-moving traveler.

Nature for October 25 contains an excellent steel portrait of Sir Joseph Hooker as one of the series of Scientific Worthies; the accompanying biographical notice is by his companion in American travel, Professor Gray, but was written in May, and was in type before Sir Joseph reached this country. The same number of Nature contains two pages of Notes on the Botany of the Rocky Mountains, a brief sketch, drawn up by him on the homeward voyage. A. G.

5. GEORGE HADLEY, M.D., Professor of Chemistry in the University of Buffalo, died, at Buffalo, N. Y., Oct. 16, in the 63d year of his age. So passes to his rest the last and the oldest of the three gifted sons of gifted and most excellent parents. The subject of this notice, called to a less conspicuous position, did not attain the eminence of his brother James, but rather followed in the footsteps of his father, Professor James Hadley, the first Professor of Chemistry in the Medical College of the Western District, N. Y., at Fairfield, then at Geneva, and lastly at Buffalo, where his son succeeded him. The father and the son were singularly alike, model teachers and model men, truthful to the core and loveable exceedingly, modest and quiet to a degree that masked from the world their ability and their learning: but these traits could not be hidden from those who in two generations came under their influence and shared their abiding friendship. From the father the writer of these lines received, when a youth of sixteen, his first help as a student of botany, and later his first encouragement in essaying a scientific career. He would lay this tribute to the memory of both father and son upon the tomb now opened to receive the mortal remains of the latter. A. G.

6. JOHN DARBY, who graduated in 1831 at Williams College, was born in North Adams, Mass., Sept. 27, 1804. His life was devoted with remarkable steadfastness to teaching in the departments of Mathematics, Chemistry and Natural History, for which he had a great fondness. For some years after his graduation he taught these subjects at the Barhamville Female Institute in Columbia, S. C. He subsequently taught the same subjects for many years in the Georgia Female College at Macon. He filled the chair of Mathematics for one year in Williams College, his alma mater. From this chair Professor Darby went to Auburn in Alabama as Professor of Chemistry and Natural History in the East Alabama College, where he continued until his death in August, 1877.

Professor Darby's scientific work outside the time occupied in teaching—to which he ever gave a most conscientious and willing devotion—was chiefly in botany, of which science he was an enthusiastic student. In 1855 he published his "Botany of the Southern States," in two parts: I. Structural and Physiological Botany and Vegetable Products. II. Descriptions of Southern Plants, arranged on the natural system, preceded by a Linnæan and Dichotomous Analysis. In a critical notice of Professor Darby's work, Dr. Gray (this Journal, vol. xx, p. 131, 1855), says, "the book is excellently planned, and is well adapted to its purpose, —that of a text-book for the Colleges and High Schools of the

Southern States." Professor Darby also published a Class-book of Chemistry. He was married August 20, 1833, to Miss Julia P. Sheldon, daughter of Calvin Sheldon, of Manchester, Vt. Professor Darby enjoyed the enviable reputation of a man of high character and pure life, zealously devoted to teaching in his chosen departments. R. S.

7. *Herbarium for sale.*—The herbarium of the late Arthur Schott is offered for sale, for the benefit of his family. It is said to contain 7,000 species, in good condition, and to be rich in plants of the U. S. and Mexican Boundary, of Mexico, and of Central America; a good many from Southern Germany and Hungary. Application to be made to H. Schott, Georgetown, D. C.

8. *Zoological Diagrams;* by LEUCKART and NITSCHE.*—Professors R. Leuckart and H. Nitsche have just issued the first number of an extended series of zoological diagrams for the use of universities and schools. They propose to issue from one hundred to one hundred and ten such diagrams, both plain and colored, to illustrate the structure and development of the principal forms of animal life. They intend to copy their illustrations mainly from the monographs of special investigators of acknowledged excellence, and to reproduce the figures of a sufficient size to be easily seen in a class-room of moderate dimensions. The diagrams are to be accompanied by an explanation of the figures, with German, French and English text. The authors intend to take special care not to follow any school of zoology and always to indicate in the text the sources from which their figures have been derived; they do not propose to follow a strictly systematic order in the issue of the parts, but the separate numbers will always contain figures from different types and groups of the animal kingdom. Professors Leuckart and Nitsche will indicate by their initials the plates for which each is personally responsible. The plates are issued at a very moderate price, at far less than an ordinary draughtsman can afford to make similar diagrams.

The three plates of the first number are devoted to Corals, Rhizopods and Isopods; the coloring of the various organs and of special parts is identical in the different figures, thus greatly facilitating the comparison of different animals.

It is a great pity that both the French and English text should be marred not only by serious misprints but also by the most extraordinary translations of the German explanation of the figures. The structure of some of the French and English sentences is truly marvellous, and we earnestly hope that the authors will employ a Frenchman and an Englishman to revise the text for the succeeding numbers. It would often puzzle a reader who does not know French and English as well as German, to make out the meaning of the text.

But these are minor defects, and if the work is carried out as it has been commenced, it cannot fail to be a most valuable guide to teachers of zoology, for they may rest assured that the distinguished editors will give them nothing which has not stood the test of time, and we most cordially recommend the series.

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* Zoologische Wandtafeln; v. Dr. R. Leuckart u. Dr. H. Nitsche. Erste Lieferung Tafel I–III. Cassel, 1877.

A. AG.

IV. ASTRONOMY.

1. *The Sun's Distance.* (Abstract of the Report of the Astronomer-Royal on the Telescopic Observations of the recent Transit of Venus, from Nature of Nov. 1).—A most interesting state paper has just been issued; we refer to the Report by the Astronomer-Royal on the Telescopic Observations of the Transit of Venus of 1874, made by the Expeditions sent out by the British Government and the results deduced from them. The Astronomer-Royal suggests that another report may be called for when the photographs of the transit have been completely measured and worked out, if possible in combination with the results of similar observations made in the expeditions organized by other governments.

It will be seen from the present report that the plan of operations actually pursued has been very nearly that proposed by the Astronomer-Royal in his communication to the Royal Astronomical Society on December 11, 1868, when for the third time directing attention to the arrangements which it would be necessary to make for the efficient observation of the transits of 1874 and 1882. The method of absolute longitudes was to be applied for observations both of ingress and egress; it being therefore essential that the longitudes of the observing stations should be determined with precision; and the longitudes recommended to be fixed by Great Britain were Alexandria, stations in New Zealand and in the Sandwich Islands, Kerguelen's Land, and Mauritius or the two islands of Rodriguez and Bourbon.

The stations eventually selected for observatins by the British expedition were fixed upon "entirely by consideration of the influence which their positions would have in determining with accuracy the necessary alteration of parallax." They were: Egypt, the Sandwich Islands, the Island of Rodriguez, New Zealand, and Kerguelen's Land. It was intended to adopt in each of these districts one fundamental station, the longitude of which was to be independently determined, for conversion of local times into Greenwich times, and subordinate to this primary station, other stations were proposed to be selected at such distances that advantage might be taken of different states of weather that might possibly prevail.

In Egypt his Highness the Khedive rendered every possible assistance, tents being supplied with military guards for the protection of the observers and their instruments, and telegraph wires erected. The Astronomer-Royal acknowledges the obligations of the expedition to the liberality of the Eastern Telegraph Company, in affording the means of determining with extreme accuracy and great facility the longitude of the principal station Mokattam.

Greenwich was easily connected with Porth Curno, in Cornwall, whence there is an uninterrupted line to Alexandria, the longest submarine line in the world; Alexandria was connected with Mokattam by aid of the special line constructed by the Khedive from Cairo to the station. It is further stated that time-communication was also made from Mokattam through Cairo to Thebes, and to Suez by the ordinary telegraph, Thebes and Suez being the other Egyptian stations where the transit was observed.

In the Sandwich Islands much assistance was received from King Kalakaua and members of the reigning family. The principal station was at Honolulu, the longitude of which was determined partly by meridian-transits of the moon and partly by transits of the moon observed with the Altazimuth instrument. Waimea, in the island Kauai, where observers were also placed, was connected with Honolulu by means of chronometers carried in H.M.S. *Teredos.* At the Island of Rodriguez the longitudes were determined in the same manner as for the Sandwich Islands stations, for three positions, viz: Point Venus, the Hermitage, and Point Coton; and communication was further made with the Mauritius and with Lord Lindsay's expedition with the aid of H.M.S. *Shearwater*, the preliminary results being stated by Sir George Airy to agree closely with those given by the lunar observations. At Kerguelen's Land, again, the operations were similar; Supply Bay and Thumb Peak being the stations chosen.

In New Zealand unfavorable weather much interferred with the observations, and Sir George Airy had at first been led to suppose that all useful observation had been lost; it subsequently appeared, however, that this was not the case, one phase of the transit being well seen at Burnham, the longitude of which was fixed by meridian transits of the moon.

The report is divided into three sections or tables. In the first are given the descriptions of the various phenomena, in the words of the observers, with the Greenwich sidereal times of the different phases, obtained from accurate reduction of the observations for longitude here particularized; where such longitudes depend upon lunar observations the places of the *Nautical Almanac* were carefully corrected by observations on nearly the same days at Greenwich, Paris, Strasburg, and Königsberg. In studying these original descriptions, Sir George Airy was led to infer that it was "possible to fix upon three distinct phases for the *Ingress* and four for the *Egress*," though it might have been supposed that Egress and Ingress would exhibit the same number of distinct phases in inverse order; this was not the case in practice. The first phase, a, utilized in the calculations is the appearance of the planet just within the sun's disc, but the light between the two limbs being very obscure. After an interval of about twenty seconds "the light begins to clear, and the observers generally think that the contact is passed;" this is phase β. About twenty seconds later, the light which at phase β was not equal to that of the sun's limb, is free from all shadow, and the phase is called γ. Sir

George Airy finds that of these phases β is the most exact, observers, even in the presence of clouds of moderate density, agreeing within three or four seconds, though for other phases much greater discordances are exhibited. Similarly at the Egress, the first appearance of a fine line or faint shadow is called δ, this becoming definite, or a "brown haze" appearing, is called ϵ. When most observers record "contact," the shadow having reached a maximum intensity, the phase is called ζ, and in this phase there is an agreement amongst observers, much closer than in other phases at Egress. The "circular" contact at Egress is called η.

In the second section of the report, or Table II, these "adopted phases are massed for each district in which the parallax-factor is nearly identical," and several of the details of reduction are included. With the longitudes determined as above, the recorded time of the various phases of the transit were converted into Greenwich sidereal times. With the calculated apparent places of the sun and Venus in the *Nautical Almanac*, as deduced from Leverrier's Tables, an ephemeris was prepared exhibiting the predicted geocentric places for every tenth second of Greenwich sidereal time throughout the transit, and from these numbers the apparent positions of sun and planet at each station were computed. Calculations were further made, showing how the predicted places would be affected by alteration of the local longitude, by change in the tabular places of the sun and Venus, and by alteration of their tabular parallaxes; the first two alterations were not essential in these reductions, but the determination of alterations of the third class, as it is remarked, constituted "the special object of the expedition." The form of the reductions was "entirely determined by the consideration that such alterations must be made in the parallaxes as will render the observations of the same phenomena in different parts of the earth consistent with each other." In Table III. we have "the mean solar parallax deduced from every available combination." Thus Ingress accelerated at the Sandwich Islands is compared with Ingress retarded at Rodriguez and with Ingress retarded at Kerguelen's Land; Egress retarded at Mokattam and Suez with Egress retarded at Rodriguez, and likewise with Egress accelerated at the two stations in Kerguelen's; and again the retarded Egress at Thebes is compared with Egress retarded at Rodriguez and with Egress accelerated at Kerguelen's. The greatest separate value of the solar parallax resulting from these different comparisons is 8″·933 and the least 8″·407. Weights are given to the various determinations depending firstly, upon the number of observations and the magnitude of the parallax-factor; and secondly, upon the particular phase α, β, γ, δ, ϵ, and ζ being included. Thus it is found that all the combinations for *Ingress* give the mean solar parallax 8″·739, weight 10·46, and all the combinations for *Egress* give 8″·847, weight 2·53, whence the general result is 8″·760, from which Sir George Airy finds the mean distance of the sun equal to 93,300,000 miles. The New Zealand observations were not included in these calculations; their mean result is 8″·764, almost identical with the above. It is remarked that many persons may perhaps consider that the more closely-agreeing phases β and ζ should be employed in deducing the value of the parallax to the exclusion of the others. If this be done we shall have from the *Ingress* 8″·748, and from the *Egress* 8″·905, or with their due weights a mean value 8″·773.

In this outline of the details contained in the Astronomer-Royal's first report upon the observations of the transit of Venus, and the conclusions to be drawn from them we have adhered closely to his own words. Pending the appearance of the deductions to be made from the complete measuring of the photographs, the results before us are perhaps to be regarded as provisional ones only, or we have not yet learned all that may be done from the work of the British expeditions, so laboriously organized by Sir George Airy. Many astronomers we can imagine will regard with some suspicion so small a parallax as 8″·76, which is a tenth of a second less than has been given by the most reliable previous investigations, upon different principles. In illustration we may quote the separate results from which Prof. Newcomb obtained his value of the parallax, now adopted in most of our ephemerides:—

From meridian observations of Mars, 1862	8″·855
From micrometric observations of Mars, 1862	8″·842
From parallactic inequality of the moon	8″·838
From the lunar equation of the earth	8″·809
From the transit of Venus, 1769 (Powalky's reduction)	8″·860
From Foucault's experiments on light	8″·860

To these may be added Leverrier's value subsequently deduced from the planetary theories, which is also 8″·86. Newcomb's mean figure, taking account of weights corresponding to the probable errors is 8″·848, which, with Capt. Clarke's measure of the earth's equator, implies that the mean distance of the sun is 92,393,000 miles. Sir George Airy's 8″·760 would similarly place the sun at a mean distance of 93,321,000 miles.

It is well known that some astronomers have not expected our knowledge of the sun's distance to be greatly improved from the observations of the transit of Venus, regarding such an opportunity as is presented by a close opposition of Mars as affording at least as favorable conditions, and the result of Mr. Gill's expedition to Ascension to utilize the late opposition will be on this account awaited with much interest. Nevertheless, whatever degree of opinion might be entertained by competent authorities, it appears to have been felt by those immediately responsible for action, in different civilized nations where science is encouraged, that so rare a phenomenon as a transit of Venus could not be allowed to pass without every exertion being made to utilize it, and this country may lay claim to an honorable share in the great scientific effort, thanks mainly to the long-continued and admirably-directed endeavors of the Astronomer-Royal to secure this result.

Several of the stations occupied during the transit of 1874 will be available for the transit of 1882, Kerguelen's Land in particular, where at Ingress the sun will be at an elevation of 12°, the factor of parallax being 0·98. In that year there will also be the advantage of observations along the whole Atlantic sea-board of the United States and Canada, where, as pointed out by the Astronomer-Royal in 1868, the lowest factor is 0·95, and the smallest altitude of the sun 12° for observing the retarded Ingress; and for observing the Egress as accelerated by parallax, the factors are about 0·85, the sun's elevation varying from 4° at Halifax, to 32° at New Orleans, or Jamaica. Australian and New Zealand stations are important for retarded Egress.

As is well known, the transit of Venus on December 6, 1882, will be partly visible in this country.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Notes on the Rocky Mountains;* by Sir JOSEPH HOOKER. (From Nature of Oct. 25.)—In company with Dr. Asa Gray, Professor of Botany of Harvard University, Cambridge, U. S., I availed myself of an oft-repeated invitation to us both from Dr. Hayden, the distinguished chief of the Topographical and Geological Survey of the United States Territories, to join the Survey in Colorado and Utah; this we did with the view of instituting a comparison between the floras of these central and elevated territories and those of other parts of the continent, and thus obtaining some insight into the origin and distribution of the North American flora. In order to comprehend the importance of Colorado and Utah as the basis for such investigations, I should state that they occupy a very central position in the continent, and include a section of the Rocky Mountains about 300 miles long and about as broad, namely, from N. lat. 37° to 41°, and from W. long. 105° to 112°.

The mountain region thus limited consists of extensive and often level-floored valleys, sometimes many miles broad, and elevated 4,000 to 5,000 feet above the sea, called "parks" in local topography, which are interposed between innumerable rocky mountain ridges of very various geological age and formation, which often reach 12,000 feet, and sometimes 14,000 feet elevation, the maximum being under 14,500.

Those of the so-called parks which are watered by rivers that flow to the east are continuous with the prairies that lie along the eastern flanks of the Rocky Mountains; those watered by rivers that flow to the west are continuous with the so-called desert or salt regions that lie along the western flanks of the range; but the divides between the head waters of the streams that flow either way are sometimes low, and the botanical features of the east and west may hence meet and mix in one park.

Such a section of the Rocky Mountains must hence contain representatives of three very distinct American floras, each characteristic of immense areas of the continent. There are two temperate and two cold or mountain floras, viz: (1) a prairie flora, derived from the eastward; (2) a so-called desert and saline flora, derived from the west; (3) a sub-alpine; and (4) an alpine flora; the two latter of widely different origin, and in one sense proper to the Rocky Mountain ranges.

The principal American regions with which the comparison will have first to be instituted are four. Two of these are in a broad sense humid; one, that of the Atlantic coast, and which extends thence west to the Mississippi River, including the forested shores of that river's western affluents; the other that of the Pacific side, from the Sierra Nevada to the western ocean: and two inland, that of the northern part of the continent extending to the Polar regions, and that of the southern part extending through New Mexico to the Cordillera of Mexico proper.

The first and second (Atlantic plus Mississippi and the Pacific) regions are traversed by meridional chains of mountains approximately parallel to the Rocky Mountains; namely, on the Atlantic side by the various systems often included under the general term Appalachian, which extend from Maine to Georgia, and on the Pacific side by the Sierra Nevada, which bounds California on the east. The third and fourth of the regions present a continuation of the Rocky Mountains of Colorado and Utah, flanked for a certain distance by an eastern prairie flora, extending from the British possessions to Texas; and a western desert or saline flora, extending from the Snake River to Arizona and Mexico. Thus the Colorado and Utah floras might be expected to contain representatives of all the various vegetations of North America except the small tropical region of Florida, which is confined to the extreme southeast of the Continent.

The most singular botanical feature of North America is unquestionably the marked contrast between its two humid floras, namely, those of the Atlantic plus Mississippi, and the Pacific one; this has been ably illustrated and discussed by Dr. Gray in various communications to the American Academy of Sciences, and elsewhere, and he has further largely traced the peculiarities of each to their source, thus laying the foundations for all future researches into the botanical geography of North America; but the relations of the dry intermediate region either to these or to the floras of other countries had not been similarly treated, and this we hope that we have now materials for discussing.

Our course and direction in America was directly westward to Colorado, where we followed the eastern flanks of the Rocky Mountains for about 300 miles, that is from Denver in the north, to near the borders of New Mexico, ascending the highest northern and southern peaks, and visiting several intermediate parks and valleys, watered by tributaries of the Arkansas, Platte, Colorado, and Rio Grande. From Denver we proceeded north to Cheyenne in Wyoming, and thence westward by the Central Pacific Railway, across the range to Ogden, and the Great Salt Lake in Utah, which lies on the base of the Wahsatch Mountains, themselves the western escarpment of the Rocky Mountains proper in that latitude. After ascending these we proceeded westward by rail through Utah, to Nevada, thus crossing the great dry region that intervenes between the Rocky Mountains and the Sierra Nevada, which is variously known as the Desert, Salt, or Sink region of North America, in accordance with the prevailing features of its several parts. It is elevated 3,850 to 6,000 feet, and traversed by numerous short meridional mountain-ridges, often reaching 8,000 feet, and rarely 10,000 feet elevation; unlike the Rocky Mountains or over the Sierra Nevada, these present no forest-clad slopes, and only the highest have a limited Alpine flora.

From Reno, at the western base of the Sierra Nevada, we proceeded south by Carson City, flanking the Sierra for some sixty miles to Silver Mountain, when we struck westward, ascending the Sierra, which was crossed obliquely into the Pacific slope. There we visited three groves of the "Big Trees" (*Sequoia gigantea*) at the headwaters of Stanislaus and Tuolomne Rivers, and the singular Yosemite Valley, whence we descended into the great valley of California, and made for San Francisco.

From the latter place we made excursions first to the old Spanish settlement of Monterey, which is classical ground for the botanist, as being the scene of Menzies' labors during the voyage of our countryman, Capt. Vancouver, in 1798 (whose surveys are held in the highest estimation by Professor Davidson and the officers of the Coast Survey of the United States), whom he accompanied as botanist. Then we went northward along the coast range to Russian River to visit the forests of Red-wood (*Sequoia sempervirens*), the only living congener of the Big Trees, and almost their rival in bulk and stature. Then to Sacramento, and up the valley of that name for 150 miles to Mount Shasta, a noble forest-clad volcanic cone about 14,400 feet in elevation. Returning thence to Sacramento we took the Union Pacific Railway eastward, and from the highest station visited Mount Stanford, on the crest of the Sierra Nevada, and Lake Tahoe, which occupies a basin in the mountains at about 7,000 feet elevation, and with which we finished our western journeyings.

In California the Coniferæ were a principal study, with a view of unraveling their tangled synonymy and tracing the variations and distribution of these ill-understood trees, which attain their maximum development in number of species and in stature on the Pacific slope of the American continent.

The net result of our joint investigation and of Dr. Gray's previous intimate knowledge of the elements of the American flora is, that the vegetation of the middle latitudes of the continent resolves itself into three principal meridional floras, incomparably more diverse than those presented by any similar meridians in the old world, being, in fact, as far as the trees, shrubs, and many genera of herbaceous plants are concerned, absolutely distinct. These are the two humid and the dry intermediate regions above indicated.

Each of these, again, is subdivisible into three, as follows:—

(1.) The Atlantic slope plus Mississippi region, subdivisible into (α) an Atlantic (β) a Mississippi valley, and (γ) an interposed mountain region with a temperate and sub-alpine flora.

(2.) The Pacific slope, subdivisible into (α) a very humid cool forest-clad coast range; (β) the great hot drier Californian valley formed by the San Joaquin River flowing to the north, and the Sacramento River flowing to the south, both into the Bay of San Francisco; and (γ) the Sierra Nevada flora, temperate, sub-alpine, and alpine.

(3.) The Rocky Mountain region (in its widest sense extending from the Mississippi beyond its forest region to the Sierra Nevada), subdivisible into (α) a prairie flora; (β) a desert or saline flora; (γ) a Rocky Mountain proper flora, temperate, sub-alpine, and alpine.

As above stated, the difference between the floras of the first and second of these regions, is specifically, and to a great extent generically absolute; not a pine or oak, maple, elm, plane, or birch of Eastern America extends to Western, and genera of thirty to fifty species are confined to each. The Rocky Mountain region, again, though abundantly distinct from both, has a few elements of the eastern region and still more of the western.

Many interesting facts connected with the origin and distribution of American plants and the introduction of various types into the three regions, presented themselves to our observation or our minds during our wanderings; many of these are suggestive of comparative study, with the admirable results of Heer's and Lesquereux's investigations into the pliocene and miocene plants of the north temperate and frigid zones, and which had already engaged Dr. Gray's attention, as may be found in his various publications. No less interesting are the traces of the influence of a glacial and a warmer period in directing the course of migration of Arctic forms southward, and Mexican forms northward in the continent, and of the effects of the great body of water that occupied the whole saline region during (as it would appear) a glacial period.

Lastly, curious information was obtained respecting the ages of not only the big trees of California, but of equally aged pines and junipers, which are proofs of that duration of existing conditions of climate for which evidence has hitherto been sought rather amongst fossil than amongst living organisms.

I need hardly add that the part I played in the above sketched journey was wholly subordinate to Dr. Gray's, who had previously visited both the Rocky Mountains and California, though not with the same object. But for his unflinching determination that nothing should escape my notice which his knowledge and observant powers could supply, and Dr. Hayden's active co-operation, my own labors would have been of little avail.

Moreover, throughout the expedition we experienced great hospitality, and enjoyed unusual facilities, not only from the staff of the Geological Survey, but from the railway authorities, who franked us across the continent, and on all the branch lines which we traversed.

2. *The Earths of the Cerium Groups as found in the North Carolina Samarskite.*—In my original paper and subsequent note on this group of earths as separated by sulphate of potash from the mixed earths of North Carolina samarskite, I then stated that oxide of cerium was not to be ranked among them. I have continued the researches in this direction, and while they are far from being complete, it is pretty well determined that the bulk of the earth separated by the sulphate of potash is a *new earth*, if it be not *oxide of terbium*, an earth the existence of which is denied, and of the properties of which we have but a very imperfect knowledge. The other oxides of this group are thoria and oxide of didymium. I am still prosecuting my researches, and hope before long to give more positive results.—*J. Lawrence Smith's letter of Nov.* 14.

3. *Artificial Tremors through the Earth's Crust*, at the time of the Hallet's Point explosion in August and September, 1876; abstract of a paper by Henry L. Abbot, Major of Engineers, Bvt. Brig. General, read before the National Academy of Sciences at its recent meeting in New York.—Mr. Mallet's results, reported many years ago to the Royal Society, were:

Velocity in ft. per second in sand,	825 ft.
" " " in discontinuous and much shattered granite,	1306 ft.
" " " in more solid granite,	1665 ft.
" " " in quarries at Holyhead (mean),	1320 ft.

The results, obtained by the officers of the United States Engineer School of Application at Willet's Point, for the rate through drift formation of Long Island, are the following:

TABLE I.

No. of observations.	Date.	Observer.	Cause of Shock.	Distance to station.	Type of seismometer.	Tremor of mercury. Arrived in	Tremor of mercury. Lasted for	Velocity of transmission.
				miles.		sec'ds.	sec'ds	ft. pr sec.
1	Aug. 18, '76.	Capt. Livermore	200 lbs. dynm.	5 ±	B	5 ±		5280 ±
2	Sept. 24, '76.	Lieut. Young	Hallet's Pt. ex.	5·134	A.	7 ±	63 ±	3873 ±
3	" " "	Lieut. Griffin	" " "	8·330	B.	5·3	72·3	8300
4	" " "	Lieut. Kingman	" " "	9·333	A.	10·9	23·5	4521
5	" " "	Lieut. Leach	" " "	12·769	B.	12·7	19·0	5309
6	Oct. 10, '76.	Lieut. Kingman	70 lbs. powder.	1·360	A.	5·8	inst't	1240
7	Sept. 6, '77.	Lieut. Kingman	400 lbs. dynm.	1·169	A.	1·8	7·8	3428
8	" " "	Lieut. Leach	" " "	1·169	B.	0·7	17·8	8814
9	Sept. 12, '77.	Lieut. Griffin	200 lbs. dynm.	1·340	A.	1·05	8·8	6730
10	" " "	Lieut. Leach	" " "	1·340	B.	0·81	17·1	8730
11	" " "	Lieut. Griffin	70 lbs. powder.	1·340	A.	1·27	4·8	5559
12	" " "	Lieut. Leach	" " "	1·340	B.	0·84	15·1	8415

In the case of No. 6 the charge was five feet below the surface. In those of Nos. 11 and 12 the charge was thirty feet below surface, giving a much more violent shock than No. 6. Lieut. Leach reports, "I should say that it (the tremor) was at least two seconds in attaining a maximum." Hence, an instrument just capable of detecting it, would have registered only 2,489 feet.

TABLE II. (Analysis of above.)

No. of observations.	Seismometer A, (power 6).		No. of observations.	Seismometer B, (power 12).	
	Velocity of transmission.	Duration of tremor.		Velocity of transmission.	Duration of tremor.
	ft. per sec.	seconds		ft. per sec.	seconds
2	3873 ±		1	5280 ±	
4	4521		3	8300	
6	1240	instant	5	5309	
7	3428	7·8	8	8814	17·8
9	6730	8·8	10	8730	17·1
11	5559	4·8	12	8415	15·1
Mean.	4225			7475	

Conclusions. In such observations a high magnifying power of telescope is essential. The more violent the initial shock, the higher is the rate. This rate diminishes as the wave advances. For one mile, through drift formation, a severe shock gives a velocity of say 8,500 feet per second. The rate for the great Hallet's Point explosion was about 8,300 feet per second for the first eight miles, and about 5,300 feet per second for the first thirteen miles. These conclusions are supported by much additional evidence that cannot be stated in a tabular form.

4. *Recherches expérimentales faites avec les gaz produits par l'explosion de la dynamite sur divers caractères des météorites et des bolides qui les apportent*, par M. DAUBRÉE.—Professor Daubrée has carried on a series of experiments with dynamite similar to those he had previously performed with ordinary powder (Comptes Rendus, lxxxii, 949; lxxxiv, 413, 526), his design being to obtain an explanation for some of the most important characters of meteorites. Prisms of planed steel, each side having a surface of 65 mm., were subjected under different conditions, to the explosion of charges of two and of five kilograms of dynamite. The cartridge was in each case simply applied to one of the faces so as to act upon a single side only. The explosion took place at the bottom of a pit, some two meters in depth, so that all the fragments of the shattered steel could be recovered for examination. The immediate results of these experiments were as follows:—The mass acted upon was broken up into numerous polyhedral fragments, the planes of fracture being mostly perpendicular to the "*surface of action*" on which the force of the gas was felt. The surface directly exposed to the explosion showed numerous spheroidal depressions; these sometimes attained a diameter of 15 to 18 mm. and a depth of 4 to 5 mm. They were often grouped in lines, like the links of a chain, and in some cases were

bordered by an elevated ring. Outside of these distinct cavities the whole surface acted upon was fretted, or covered over with minute irregular depressions. Moreover the lateral faces showed fine, regular lines, parallel to the "surface of action," and produced by the violent crushing action of the exploded gas; and further, when these lateral faces were polished and etched with dilute acid, it was found that the parts close to the surface exposed to the gas had a peculiar tint which probably resulted from a sort of tempering which the surface had undergone from its rapid cooling. Again, of the fracture-surfaces, aside from those showing only a ragged break, some were polished and others finely striated, results which were due to the rubbing of the parts against each other at the instant of fracture. Finally, numerous cracks in the fragments of steel were compactly filled with the clay and sand from the walls of the pit, which had been forced into them. Characters analogous to those above enumerated as produced on the steel by the action of exploding dynamite, are commonly observed on meteorites; these are:—their fragmentary, polyhedral form; the pitted or "*piezoglyptic*" (graven under strain or pressure) character of their surfaces; the change of texture near the surface in the case of iron meteorites; the striated, fibrous surfaces in the interior of the mass, due to the rubbing of the parts against each other; the black veins ("lignes noires") resulting from a portion of the fused surface being pressed into cracks in the interior; and finally, the black marbled surface.

Professor Daubrée concludes that, as in the case of steel subjected to the action of dynamite, so also with the bolides and meteorites the effects observed are due mostly to the action of strongly compressed and hence highly heated gas. Although it is impossible to estimate, even approximately, the pressure exerted upon a bolide, from the time it enters the atmosphere until it explodes and scatters its fragments upon the earth, the conclusion is notwithstanding justified that it is comparable to the pressure exerted by the gas in the experiments with dynamite.

The writer would also ascribe the production of the large number of individual stones which have characterized some falls, as that of Pultusk in 1868, to the fracturing of an original mass by the compression of the air, and not by the unequal contraction due to a heated surface and a cold interior. He also calls attention to the fact that the "piezoglyptic" character of the surface is true of the whole meteorite, and not to one side only, and concludes from this that the moving mass must have had a motion of rotation, so that the different surfaces were in succession placed in front and subjected to the action of the compressed air.—*C. R.*, lxxxv. E. S. D.

5. *National Academy of Science.*—At a session held at Columbia College, N. Y., Oct. 23-25, 1877, the following papers were read:

Stephen Alexander.—(1.) On the laws of extreme distances in the Solar system.—(2.) On the inclinations in a direction retrograde of the shadow of the planets.—(3.) On the luminous band which seems to encircle the moon during a partial solar eclipse.—(4.) Whence came the inner satellite of Mars?

A. M. Mayer.—On a new and simple method of determining the number of vibrations of sonorous bodies.

A. Agassiz.—On the development of Flounders.

T. Gill.—On the Morphology of the Antlers of the Cervidæ.

Elias Loomis.—Contributions to Meteorology (*eighth paper*).

Henry L. Abbot.—Velocity of transmission of shocks caused by the explosion of gunpowder and of nitroglycerine compounds, through the earth's crust.

Joseph Henry.—On the abnormal phenomena of Sound, in relation to Fog Signals,—on behalf of the U. S. Light House Board.

O. N. Rood.—(1.) On the photometric comparison of light of different colors.—(2.) On a construction for the study of the contrast of colors.

Dr. M. Ihlseng.—On a method of studying of velocity of Sound in Wood. Presented by O. N. Rood.

J. S. Newberry.—(1.) On some new fossil Fishes from Ohio and Indiana.—(2.) On the geological age of the Western Lignites.

J. Lawrence Smith.—(1.) Notes on the analysis of Columbates.—(2.) Notes on the native iron and basalt of Greenland.—(3.) Exhibition of specimens showing the occurrence of sulphuret of chromium in meteoric iron.

James Hall.—Note on the Hydraulic Limestone and associated strata at the Falls of the Ohio.

O. C. Marsh.—(1.) On some gigantic Dinosaurian Reptiles from the Wealden of the Rocky Mountains.—(2.) American Cretaceous Birds.

H. A. Newton.—On Comets. (Read by title.)

A. S. Packard, Jr.—On the Air-sacs of Locusts.

Joseph LeConte.—On the glycogenic functions of the Liver, and its relation to vital force and vital heat.

A. Guyot.—Biographical memoir of Louis Agassiz. 1st part, relating to his life and work in Europe.

6. *Canada and New England Earthquake.*—A paper on this recent earthquake by Prof. Rockwood, now of Princeton, N. J., will appear in another number of this Journal.

7. *Thin Sections of Rocks, Minerals, etc.*, are made to order by A. A. Julien, School of Mines, Columbia College, New York, who also has made arrangements for sawing and polishing rocks, and polishing and etching meteorites. He has also collections of slides of various rocks on sale.

OBITUARY.

James Orton, Professor of Natural History in Vassar College, died in Bolivia about the 24th of September while crossing Lake Titicaca, and lies buried on a little island in the lake. He was born at Seneca Falls, N. Y., in the year 1830, and graduated at Williams College in 1853. Professor Orton was on his third tour to South America. In 1867–68, he took charge of an expedition to the Upper Amazons, under the auspices of the Smithsonian Expedition and along with a party from Williams College; and, in 1873, he made a second exploration of the Amazon, penetrating to Bolivia. About ten months since he left for his third exploring tour, with the design of tracing the waters of Eastern Bolivia to the Amazon. This Journal contains communications from Professor Orton, in volumes for the years 1868, 1869, on points in the Physical Geography of Quito and of the Andes and Amazons, and on the Geology of the Andes of Ecuador; and in 1870, appeared his work entitled "The Andes and the Amazon, or across the Continent of South America," giving a full account of his observations and discoveries.

APPENDIX.

ART. LII.—*A New Order of Extinct Reptilia (Stegosauria) from the Jurassic of the Rocky Mountains;* by Prof. O. C. MARSH.

THE Museum of Yale College has recently received the greater portion of the skeleton of a huge reptile, which proves to be one of the most remarkable animals yet discovered. It was found on the eastern flank of the Rocky Mountains, in beds which I have regarded as corresponding nearly to the Wealden of Europe, and which may be classed as upper Jurassic. The remains are well preserved, but are embedded in so hard a matrix that considerable time and labor will be required to prepare them for a full description. The characters already determined point to affinities with the Dinosaurs, Plesiosaurs, and more remotely with the Chelonians, and indicate a new order, which may be termed *Stegosauria*, from the typical genus here described.

Stegosaurus armatus, gen. et sp. nov.

In this specimen, some of the teeth preserved have compressed crowns, and are inserted in sockets Others are cylindrical, and were placed in rows, either in thin plates of imperfect bone or in cartilage. The latter are especially numerous, and may possibly prove to be dermal spines, having all the essential characters of teeth, as in some fishes. The vertebræ are biconcave, their neural arches being coosified with the centra, and the chevrons articulated. The limb bones indicate an aquatic life. The body was long, and protected by large bony dermal plates, somewhat like those of *Atlantochelys* (*Protostega*). These plates appear to have been in part supported by the elongated neural spines of the vertebræ.

The length of one of the compressed teeth of this species is 112 mm., and the greatest diameter of the crown 24 mm. One of the cylindrical teeth is 75 mm. in length, and 7·5 in diameter. Seven of these teeth in position occupy a space of 63 mm. A trunk vertebra measures 450 mm. from base of centrum to top of neural spine, and 170 mm. to the floor of the neural canal. The extent of seven posterior caudal vertebræ is 660 mm. One of the large dermal plates was over three feet (one meter) in length.

The present species was probably thirty feet long, and moved mainly by swimming. For its discovery science is indebted to Prof. A. Lakes and Engineer H. C. Beckwith of the U. S. Navy, who found the first remains in Colorado near the locality of the gigantic *Atlantosaurus montanus*, and in essentially the same horizon.

Yale College, New Haven, Nov. 15th, 1877.

ART. LIII.—*Notice of New Dinosaurian Reptiles from the Jurassic formation*; by Professor O. C. MARSH.

THE gigantic Dinosaur, *Atlantosaurus montanus*, described by the writer in the July number of this Journal,* proves to belong to a lower horizon than at first supposed, and is really from the upper Jurassic. Additional remains of the type specimen, moreover, throw considerable light on the structure of this largest of land animals, and indicate that it is the representative of a distinct family, which may be called *Atlantosauridæ*.

In the type genus, *Atlantosaurus*, one of the most important characters is the pneumaticity of the vertebræ, as mentioned in the original description. Another noteworthy feature is the absence on the femur of a third trochanter. The shaft of the bone is somewhat thickened at the point where this process should be, but the trochanter is wanting. The size of the original specimen of *A. montanus* may be estimated from the femur, which was about seven feet in length. If the animal had the proportions of a Crocodile, it was at least eighty feet long.

Apatosaurus ajax, gen. et sp. nov.†

Another gigantic Dinosaur, allied to the above, and of scarcely less interest, is represented in the Yale Museum by a nearly complete skeleton in excellent preservation. It is from the Jurassic beds in the Eastern foot hills of the Rocky Mountains, but from a somewhat lower horizon than the type of *Atlantosaurus*.

The cervical vertebræ are strongly opisthocœlous, and are rendered comparatively light by large pneumatic cavities in the centra. The anterior dorsals have similar characters. The posterior lumbars have the articular faces very nearly flat, and transverse. The sacral vertebræ are more solid, and have their transverse processes nearer the middle of the centra than in *Atlantosaurus*. The anterior caudals are biconcave, and their interior structure is cancellous. The chevron bones differ from those of most known Dinosaurs in having the superior articular ends of the rami not united, but separated from each other, as in the Mosasauria with free hæmapophyses.

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* Vol. xiv, p. 87, 1877. The name *Titanosaurus* was first given, but, being preoccupied, may be replaced by *Atlantosaurus*.

† The principal characters of this genus and its nearest allies were given by the writer in a paper before the National Academy of Science, at the meeting in New York, October 25th, 1877.

Some of the dimensions of this skeleton are as follows:

Length of centrum of anterior dorsal vertebra	220·mm
Transverse diameter of anterior face	310·
Vertical diameter	200·
Amount of convexity	90·
Length of centrum of lumbar vertebra	240·
Transverse diameter of anterior face	410·
Vertical diameter	270·
Length of median sacral vertebra	250·
Expanse of its transverse processes	760·
Length of centrum of median caudal	190·
Length of posterior caudal	185·

This animal must have been between fifty and sixty feet in length, and more than thirty in height when erect.

Apatosaurus grandis, sp. nov.

Another huge Dinosaur, apparently of the same genus, but of smaller size, is represented in the Yale Museum by the more important parts of a skeleton, in remarkable preservation. In this specimen the cervical vertebræ have the walls of the centra very thin. The caudals preserved are elongated and slender, indicating a long tail. The femur is comparatively short, and without a third trochanter. The great trochanter is much lower than the head of the femur, and continuous with it. The metapodial bones indicate a foot of medium length.

The following measurements indicate the size of the reptile:

Length of femur	1050·mm.
Transverse diameter of proximal end	340·
Transverse diameter of distal end	290·
Length of posterior caudal vertebra	145·
Vertical diameter of anterior articular face	110·
Transverse diameter	115·

The known remains of this species are from the same geological horizon as those above described. They indicate an animal at least thirty feet in length.

Allosaurus fragilis, gen. et sp. nov.

This genus may be distinguished from any known Dinosaurs by the vertebræ, which are peculiarly modified to ensure lightness. Although apparently not pneumatic, they have the weight of the centra greatly reduced by deep excavations in the sides. Some of them have the centra hour-glass in form, the middle part being so diminished as to greatly reduce the strength. The vertebræ preserved are biconcave, with shallow cavities. The feet bones referred to this species are very slender. A lumbar vertebra has its centrum 105 mm. in length, and 89 in least transverse diameter. An anterior caudal, 85 mm. long, has its centrum so much constricted that its least transverse diameter is 38 mm., while its anterior face is 90 mm. in transverse diameter.

The animal indicated by the remains preserved was from fifteen to twenty feet in length. All the known specimens are from the upper Jurassic of Colorado.

Nanosaurus rex, sp. nov.

A diminutive Dinosaur, about as large as a fox, is indicated by some remains in good preservation, the most characteristic of which is a nearly perfect femur. In this bone, the great trochanter is prominent, and the third trochanter especially so. There is a well developed fibular ridge, directed outward and backward. The cavity in this bone is unusually large, and the walls are smooth. This femur agrees so nearly with that of the type of *Nanosaurus*, that the present species may be provisionally referred to that genus.

The dimensions of this bone are as follows:

Length of femur	100· mm
Distance from head to middle of third trochanter	30·
Transverse diameter of distal end	21·
Greatest antero-posterior diameter	18·
Least transverse diameter of shaft	11·
Diameter across third trochanter	15·

The known remains of this reptile are from the upper Jurassic of Colorado.

The specimens described in the present articles are deposited in the Peabody Museum of Yale College. They are all from essentially the same geological horizon, which I find to be upper Jurassic. The deposits which contained them may be called the Atlantosaurus beds, from their most characteristic fossils, the huge Dinosaurs of that genus.

Yale College, New Haven, November, 1877.

INDEX TO VOLUME XIV.*

A

Abbott, H. L., artificial tremors through the earth's crust, 509.
Academy, National, publications of, 167.
  October meeting, 511.
  Nat. Sci. Phil., Journal of, 78.
  of Sciences, St. Petersburg, 167.
  Wisconsin, transactions of, 78.
Acid, phyllic, from leaves, 483.
  rosolic, from cresol and phenol, 414.
  salicylic, method of producing, 66.
  tartronic, from pyruvic, 310.
Acids, constitution of unsaturated dibasic, 413.
  complex inorganic, *Gibbs*, 61.
Agassiz, A., N. American star-fishes, 73.
  zoological notices, 500.
Airy, G., sun's distance, 501.
Allen, J. A., influence of physical conditions in the genesis of species, 161.
  North American rodentia, not., 422.
Allen, O. D., hatchettolite and samarskite, 128.
Amylene from amyl iodide, 412.
Anthropology, *Galton*, 265.
Archæologists, caution to, 333.
Archæology, Peabody Museum of, Report, 246.
Armsby, H. P., absorption of bases by the soil, 25.
Association, American, 76.
  Nashville meeting, 328.
    Marsh's address, 337.
  British, Plymouth, 334.
    Galton's address, 265.
Astronomical observations, Harvard College, 75.
  Cincinnati, 246.
  Washington, 74.
Atterberg, the terpenes of Swedish wood tar, 412.
Aurin, conversion of into rosaniline, 310.
Autography, practical use of, *Sars*, 277.

B

Baker, J. G., Iridaceæ, 428.
Barker, G. F., chemical abstracts, 64, 148, 309, 411, 481.
Barnard, C., Light, 419.
Bean, T. H., two new species of fishes, 470.
Becquerel, H., rotatory polarization, 417.
Bennett, A. W., rapid growth, 243.
Bermudas, fishes of, *Goode*, 289.
Berthelot, effect of pressure on chemical action, 64.
Bolton, H. C., organic acids in examination of minerals, 495.
Börnstein, influence of light upon electrical resistance of metals, 152.
BOTANY—
  Algæ. North American, 72.
  "Artichokes," native, 428.
  Athamantha Chinensis, 160.
  Flora Brasiliensis, 427.
  Fungi, diseases caused by, 426.
  Growth, abnormal, in an apple-tree, *Meehan*, 243.
    rapid, 243.
  Growth-rings in exogens, *Warring*, 394.
  Impatiens, cleistogamy in, 497.
  Lichens, reproductive organs of, 72.
  Megarrhiza, germination of, *Gray*, 21.
  New Jersey, catalogue of plants, 498.
  Nomenclature, *Gray*, 158.
  Orchis rotundifolia, *Gray*, 72.
  Pithophoraceæ, 71.
  Rocky Mountains, *Hooker*, 505.
  Wild flowers of America, 497.
  See also under GEOLOGY.
Bottomley, J. T., Dynamics, 168.
Bougarel, phyllic acid, extracted from leaves, 483.
Bourgoin, action of bromine upon pyrotartaric acid, 150.
Boutlerow, isobutylene, 66.
Brohnensieg, G. C. W., Year book of botanical literature, 160.
Bromine, action of, upon pyrotartaric acid, 150.
Burnham, S. W., double-star discoveries, 31.
Bussey Institution, Bulletin of, 168.

C

Capillarity, Gauss's theory of, 152.
Carbonates and oxalates, 482.
Carnelley, determination of high melting points, 65.
Caton, J. D., Antelope and deer of America, 426.
Cavern exploration in Devonshire, *Pengelly*, 299.

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* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

Cayley, A., Elliptic functions, 76.
Cazeneuve, hematin, 311.
Chambers, G. F., Handbook of descriptive astronomy, 163.
Chapman, *E. J.*, supposed fossil tracks, Protichnites and Climatichnites. 240.
Chastaing, *P.*, influence of light in chemical changes, 416.
Cheney, *M. S.*, estimation of nickel in pyrrhotites and mattes, 178.
China, Richthofen, 487.
  löss of, 488.
Chisholm, H. W., science of weighing and measuring, 431.
Chloral, hexyl, 310.
Christie, W. H. M., the Observatory, 76.
Christomanos, specific gravity of a readily decomposable body, 64.
Chronometers, researches on, 164.
Ciamician, new vapor density method, 66.
Clarke, *F. W.*, iodates of cobalt and nickel, 280.
  specific gravity determinations, 281.
  sylvanite from Colorado, 286.
Coan, *T.*, volcanic eruptions on Hawaii, 68.
Cobalt, iodates of, *Clarke*, 280.
Coloring matter, new. 414.
Comet, Tempel's, orbit of, 430.
Comets in 1877, 430.
  observations of. *Peters*, 60.
Connecticut, elevations in, 157.
Conrad, metalacetyl-acetic ethers, 483.
Cooke, *J. P.*, physical notices, 152, 415.
  the radiometer, 231.
  density of vapors, 484.
Cooper, *J. G.*, age of the Tejon group, California, 321.
Coues, E., fur-bearing animals, 422.
  North American Rodentia, 422.
Coumarin, formation of, 67.
Crafts, synthesis of hydrocarbons, 411.
Crova, *A.*, sun's heat, 416.

D

Dale, conversion of aurin into rosaniline, 310.
Dall, W. H., names of Brachiopoda, 426.
  North American ethnology, 431.
Dana, *E. S.*, ethylidenargentamine-ethylidenammonium nitrate, 198.
  garnets from the trap rocks of New Haven, 215.
  mineralogical notes, 241, 423, 510.
Dana, *J. D.*, Wing's discoveries, 36.
  Geology of Vermont and Berkshire, 37, 132, 202, 257.
  White Mountain geology, 319.
  note on the Bernardston Helderberg formation, 379.
Daubrée, meteorites, characters of, 510.
Davyum, 482.
Delachanal, analysis of alkaline sulphides and sulpho-carbonates, 418.
Draper, *H.*, discovery of oxygen in the sun, 89.
Draper, *J. C.*, zirconia for the oxyhydrogen light, 208.

E

Earthquake, wave of May, 1877, 17, 166.
  of Jalisco, Mexico, 158.
Earth's axis, shifting of, 70.
Earths in North Carolina samarskite, 509.
Eddy, H. T., new constructions in graphical statics, 335.
Elevation, see HEIGHT.
Eltekoff, amylene from amyl iodide, 412.
Entomological Commission, Bulletin of, 74.
Ethers, metalacetyl-acetic, 483.
Ethylidenargentamine-ethylidenammonium nitrate, *Mixter*, 195, *Dana*, 198.
Euxanthon, constitution of, 484.

F

Farlow, *W. G.*, botanical notices, 71, 72.
  diseases of plants caused by fungi, 426.
Favre, A., glaciers of the Swiss Alps in the glacial era, 240.
Fittig, constitution of unsaturated dibasic acids, 413.
Fleischer's Volumetric analysis, 419.
Fossil, see GEOLOGY.
Frazer, P., Jr., Geol Report Penn., 69.
Friedel, new method for the synthesis of hydrocarbons, 411.

G

Galton, *F.*, address before British Association, 265.
Gard, analyses of cast nickel. 274.
Gases, effect of tension on spectra of, 416.
  enclosed in lignite, 481.
Genth, *F. A.*, some tellurium and vanadium minerals, 423.
Gentry, T. G., birds of Eastern Pennsylvania, 426.
GEOLOGICAL REPORTS OR SURVEYS—
  Black Hills, 321.
  Canada, 70, 427.
  Minnesota, 422.
  New Hampshire, 240, 316.
  New York, 493.
  Pennsylvania, 69.
  Portugal, 157.
  Rocky Mountains, (Powell), 431.
  Territories (Hayden), 69, 154, 420.
  Victoria, 323.

GEOLOGY—
Adirondacks, lithology of, 240.
Alleghanies, heights of, 69.
Annelids, Lower Silurian, *Grinnell*, 229.
Archæan of Canada, 313.
Berkshire and Vermont, *Dana*, 37, 132, 202, 259.
Birds, Cretaceous, *Marsh*, 85, 253.
Bowlders, large, 495.
Breccia-granite, New Hampshire, 319.
Cavern explorations in Devonshire, *Pengelly*, 299, 387.
China, 487.
Climatichnites, *Chapman*, 240.
Coal, analysis of, *Sloane*, 286.
Congress. International Geol., 491.
Connecticut valley in the Champlain and Terrace periods, *Upham*, 459.
Coryphodontidæ, *Marsh*, 81.
Crinoids, structure of Paleozoic, *Wachsmuth*, 115, 181.
Dinosaurs, new, *Marsh*, 87, 254, 514.
Earth, critical periods in the history of, *Le Conte*, 99.
Falls of St. Anthony, recession of, 423.
Fishes of Green River shales, 256, 422.
Geological Record, 1875, 423.
Glaciers of the Swiss Alps, 240.
Gravel deposits of Boone county, Kentucky, *Sutton*, 239.
 ridges in the Merrimack valley, *Wright*, 239.
Growth-rings as indicating seasons, 394.
Hawaii, volcanic eruptions in, 68.
Helderberg in Vermont and Massachusetts, *Dana*, 379.
Insects, Tertiary of Quesnel, 322.
 from American Tertiaries, 322.
Kames in New Hampshire, 156.
Lignitic of Judith River, 154.
Limonite ore beds, *Dana*, 132.
Lithological characters, use of, *Dana*, 259, 384.
Mammals, new Tertiary, *Marsh*, 249.
New Hampshire, 316.
Odontornithes, *Marsh*, 85.
Paleozoic fossils, catalogue of, 156.
Protichnites, *Chapman*, 240.
Reptiles, new, *Marsh*, 87, 254, 513, 514.
Stegosauria, a new order of Reptiles, *Marsh*, 513.
Tejon group, age of, *Cooper*, 321.
Trap rocks, garnets from, *Dana*, 215.
Trilobites, appendages of, *Walcott*, 494.
Vermont and Berkshire, *Dana*, 37, 132, 202, 257.
 Wing's discoveries in, *Dana*, 36.

GEOLOGY—
Vertebrate life, American, *Marsh*, 337.
Vertebrates from Lignitic beds, *Cope*, 154.
 new fossil, *Marsh*, 85, 87, 249, 513, 514.
West Rock, note on, 158.
White Mountains, 317, 319.
Gibbs, W., complex inorganic, acids, 61.
Goldschmidt, new vapor density method, 66.
Goodale, G. L., wild flowers of America, 497.
Goode, G. B., catalogue of reptiles and fishes of the Bermudas, 289.
 two new species of fishes, 470.
Goodyear, W. A., coal mines of western coast of the United States, 156.
Graham, T., Chemical and physical researches, 152.
Gray, A., germination of the genus Megarrhiza, 21.
 botanical nomenclature, 158.
 botanical notices, 72, 158, 426, 497.
Grimaux, production of tartronic from pyruvic acid, 310.
Grinnell, G. B., fossil annelids from the lower Silurian, 229.

H

Habermann, on Dumas's vapor density method, 309.
Hall, A., time of rotation of Saturn, 325.
Hall, J., Paleontology of New York, 493.
Haughton, shifting of earth's axis. 70.
Hawaii, volcanic eruptions on, *Coan*, 68.
Hayden, F. V., publications of expeditions under, 69, 154, 420.
Heights in western Connecticut, 157.
Hematin, 311.
Hermann, new method of producing salicylic acid, 66.
Higgs, P., note on the telephone, 312.
Hinman, C. W., volumetric determinations by chromic acid, 478.
Hitchcock, C. H., Geology of New Hampshire, 240, 316.
Hofmann, a new coloring matter, 414.
Holden, E. S., researches on chronometers, 164.
 proper motion of the trifid nebula M. 20, 433.
Hooker, J. D., botanical excursion to Rocky Mts., 161, 505.
 return of, 498.
Huxley, T. H., American addresses, 162.
Hydrocarbons, new method for synthesis of, 411.
Hydrogen, heat of combustion of, 148.

I

Iron ores, amount of manganese in, 418.
Isobutylene, condensation of, 66.

J

Jordan, D. S., North American Ichthyology, 426.

K

Kempe, A. B., How to draw a straight line, not., 431.
Kern, *S.*, on the new metal, davyum, 482.
Kerr, *W. C.*, uranium minerals, N. Carolina, 496.
Kirkwood, *D.*, satellite of Mars and nebular hypothesis, 327.
Kloos, J. H., Geology and geography in Minnesota, 323.
Koenig, *R.*, exactitude of the French normal fork, 147.
Kurz, S., botanical publications, 427.

L

Laboratory notes of Johns Hopkins University, 67.
Lambert, *E.*, morphology of the dentary system in the human race, 323.
Langley, *S. P.*, transit observations without personal error, 55.
new method in solar spectrum analysis, 141.
Lavallée, A., Arboretum Segrezianum, 428.
Lea, *M. C.*, new developers of the photographic image, 49.
sensitiveness of silver haloids, 96.
Lead, action of saline solutions on, 411.
Le Conte, *J.*, critical periods in the history of the earth, 99.
phenomena of binocular vision, 191.
Leeds, A. R., lithology of the Adirondacks, 240.
Leidy, *J.*, remarks on the yellow ant, 244.
Leuckart, R., zoological diagrams, 500.
Light, influence of in chemical changes, 416.
on electrical resistance, 152.
Löss of China, 488.
Loomis, *E.*, contributions to meteorology, 1.

M

Macoun, J., Botany of British Columbia, 427.
Mallet, *J. W.*, sipylite, a niobate, 397.
Mallet, R., volcanoes, 157.
Manganese, rose-colored sulphide of, 418.
Marsh, *O. C.*, characters of Coryphodontidæ, 81.
characters of the Odontornithes, 85.
new and gigantic Dinosaur, 87.
new vertebrate fossils, 249.
Marsh, *O. C.*, introduction and succession of vertebrate life in America, 337.
Stegosauria, a new order of reptiles, 513.
new Jurassic Dinosaurs, 514.
Mars, discovery of satellites of, 326.
Massachusetts Institute of Technology, 167.
Mathematics, American Journal of, 246.
Matthews, W., Hidasta Indians, 422.
Mayer, A. M., Light, 419.
Meehan, *T.*, abnormal growth in an apple tree, 243.
Melting points, determination of, 65.
Mermet, alkaline sulphides and sulphocarbonates, 418.
Metals, electrical deposition of, *Wright*, 169.
Meteor of June 12, 1877, *Kirkwood*, 163.
Meteoric fireballs, 75.
irons, two new, 246.
stones, description of, *Smith*, 219.
Meteorology, contributions to, *Loomis*, 1.
Meyer, *V.*, density of vapors, 484.
Miller, S. A., American paleozoic fossils, 156.
MINERALS—
Autunite, 496.
Coloradoite, 423.
Dysanalyte, 243.
Feldspars, new method of determining, *Szabó*, 241.
Ferrotellurite, 424.
Garnets from trap of New Haven, Conn., *Dana*, 215.
Gummite, 496.
Hatchettolite, *Allen*, 128.
Hetærolite, *Moore*, 423.
Labradorite of Mt. Marcy, 241.
Magnolite, 424.
Nickel, estimation of, 178.
Samarskite of North Carolina, 71, 509.
analysis of, 71, 130.
Sipylite, *Mallet*, 397.
Sphærocobaltite, 243.
Sylvanite, analysis of, *Clarke*, 286.
Tantalite from Alabama, 323.
Tellurite, 424.
Torbernite, 496.
Uraconite, 496.
Uraninite, 496.
Uranocircite, 242.
Venerite, 242.
Mixter, *W. G.*, ethylidenargentamine-ethylidenammonium nitrate, 195.
Moon, mean motion of, *Newcomb*, 401.
motion of the perigee of, 75.
Moore, *G. E.*, on hetærolite, a new mineral species, 423.
Mount Washington, points visible from, 331.

Muir, saline solutions on lead, 411.
Museum, national, Bulletin of, 426.
Museums, new American scientific, 76.

N

Naumann, C. F., Mineralogy, 424.
Nautical almanac for 1880. 327.
Nebula, motion of, *Holden*, 433.
Nebular hypothesis and satellites of Mars, *Kirkwood*, 327.
Newcomb, S., mean motion of the moon, 401.
Newton. H. A., astronomical notice, 74.
New York, museum of Natural History, report, 494.
Nickel, cast, analyses of, *Gard*, 274.
  in pyrrhotites and mattes, *Cheney* and *Richards*, 178.
  iodates of, *Clarke*, 280.
  magnet, examination of, 415.
Niemann, relation of cystin to sulphates in urine, 151.
Nilson, platoiodnitrites, 149.
Nitsche, H., zoological diagrams, 500.

O

OBITUARY—
  Anthony, J. G., 432.
  Billings, E., 78.
  Carpenter, Dr. P. P., 80.
  Conrad, T. A., 247.
  Darby, J., 499.
  Erman, A., 336.
  Fox, R. W., 248.
  Hadley, G., 499.
  Hallowell, B., 432.
  Jewett, E., 80.
  Leverrier, U. J. J., 432.
  Newton, H., 335.
  Orton, James, 512.
  Owen, Robert Dale, 80.
  Reed, Dr. Stephen, 168.
  Strong, M., 336.
  Tenney, Sanborn, 168.
  Winslow, Dr. C. F., 168.
Ost, acid obtained by action of carbon dioxide on phenol, 151.

P

Parreño, G., manganese in iron ores, 418.
Pengelly, W., cavern exploration in Devonshire, 299, 387.
Perkin, formation of coumarin, 67.
Peters, C. H. F., observations of comets, 60; a new planet, 429.
Phenanthrol, 414.
Phenol, acids obtained from, 151.
Phosphoric chloride, action on tungstic oxide, 309.
Photographic image, new developers of, *Lea*, 49.
Phyllic acid from leaves, 483.
Physics, new results in, 486.
Pickering, W. H., distant points visible from Mt. Washington, 331.
Pinner, on a hexal chloral, 310.
Planets, new, *Peters*, 429. *Watson*, 325.
Plants, see BOTANY.
Platoiodnitrites, 149.
Platt, F., Coke manufacture, 69.
Platt, F. and W. G., Geol. rep. Penn., 69.
Polaris expedition, narrative of, 245.
Polarization, magnetic rotatory, 417.
Potassium, separation from sodium, 418.
Pringsheim, germination of mosses, 71.
Pressure, effect on chemical action, 64.

R

Radiometer, *Cooke*, 231.
Rath, G. v., Mineralogische Mittheilungen, 424.
Rehs, phenanthrol, 414.
Richards, E. W., estimation of nickel in pyrrhotites and mattes, 178.
Richthofen, F. F. v., China, 487.
Riley, C. V., Insects of Missouri, 73.
Rouyaux, J. A., chronometers, 164.

S

Salicylic acid, new method for, 66.
Salzmann, euxanthon, 484.
Sars, G. O., use of autography 277.
Saturn, time of rotation, *Hall*, 325.
Schiff, new urea reaction, 67.
Schloesing, separation of potassium from sodium, 418.
Schorlemmer, aurin, 310.
Scudder, S. H., sexual dimorphism in butterflies, 244.
  insects in American Tertiaries, 322.
  Tertiary insects of Quesnel, 322.
Sea, see OCEAN.
Seeley, H. M., Vermont board of agriculture, report of, 78.
Semper, C., Anatomical publications, Würtzburg, 324.
Shepard collections, Amherst Coll., 167.
Silver haloids, sensitiveness of, *Lea*, 96.
Sloane, T. O'C., bituminous coal, 286.
Smith, J. L., meteoric stones, 219.
  tantalite, 323.
  earths in North Carolina samarskite, 509.
Smith, W., reaction between insoluble carbonates and soluble oxalates, 482.
Smithsonian report for 1876, 432.
Soil, absorption of bases by, *Armsby*, 25.
Solar, see SUN.
Soret, J. L., spectroscope with a fluorescent eye-piece, 415.
Spang, H. W., lightning protection, 77.

Specific gravity determinations, *Clarke*, 281.
  of a decomposable body, 64.
Spectroscope with fluorescent eye-piece, 415.
Spectrum analysis, solar, *Langley*, 141.
Sprague, I., Wild flowers of America, 497.
Stahl, E., reproduction of lichens, 72.
Star, double, discoveries, *Burnham*, 31.
Stars, double, 163, 246.
Stoney, G. J., a "vacuum," 311.
Streets, T. H., natural history of Hawaiian Islands, 426.
Sulphides and sulpho-carbonates, 418.
Sun and certain stars, relative ages, 74.
  discovery of oxygen in, *Draper*, 89.
Sun's distance, 501.
  heat, 416.
Sutton, G., gravel deposits, in Kentucky, 239.
Szabó, J., species of feldspars, 241.

T

Taylor, W. B., kinetic theories of gravitation, 247.
Teclu, action of phosphoric chloride on tungstic oxide, 309.
Teeth, morphology of human, 323.
Telephone, note on, 312.
Terpenes of Swedish wood tar, 412.
Than, heat of combustion of oxygen and hydrogen in closed vessels, 148.
Thomas, gases enclosed in lignite, 481.
Thomson, Sir W., and "Challenger" collections, 161.
Thorpe, T. E., Inorganic chemistry, 419.
Tice, J. H., American Meteorologist, 246.
Tides of the Arctic seas, 167.
Todhunter, I., Natural Philosophy, 77.
Transit observation, *Langley*, 55.
Tremors, artificial, through the earth's crust, 509.
Trowbridge, physical notices, 152, 486.
Tuning-fork, exactitude of, *Koenig*, 147.

U

Upham, W., origin of "kames" in New Hampshire, 156.
  Connecticut valley in the Champlain and Terrace periods, 459.
Urea reaction, new, 67.
Urine, relation of cystin to sulphates in, 151.

V

"Vacuum," nature of, 311.
Vapor-density, new method, 66.
  modification of Dumas' method, 309.
  of substances with high boiling point, 484.
Vapor volumes, 149.
Vennor, H. G., Archæan of Canada, 313.
Venus, transit of, report on, 501.
Verrill, A. E., gigantic cephalopod, 425.
  zoological notices, 73, 426.
Vermont Board of Agriculture, Rep., 78.
Villars, G., Table of logarithms, 246.
Vision, binocular, *Le Conte*, 191.
Volumetric determinations by chromic acid, *Hinman*, 478.

W

Wachsmuth, C., structure of paleozoic crinoids, 115, 181.
Walcott, C. D., trilobites appendages, 494.
Warren, S. E., Descriptive geometry, 431.
Warring, C. B., growth-rings as proof of alternating seasons, 394.
Watson, J. C., new planets, 325.
Whitaker, W., Geological Record, 423.
Whitfield, R. P., Paleontology of Black Hills, 321.
Wichelhaus, euxanthon, 484.
Wild, H., nickel magnet, 415.
Wilder, B. G., brain of Chimæra, 325.
Willis, O., plants of New Jersey, 498.
Wilson, Handbook of hygiene, 334.
Winchell, N. H., Geological report, 422.
Wittrock, V. P., Pithophoraceæ, 71.
Wright, A. W., electrical deposition of metals, 169.
  physical notices, 247, 419.
Wright, G. F., gravel ridges in the Merrimack valley, 239.

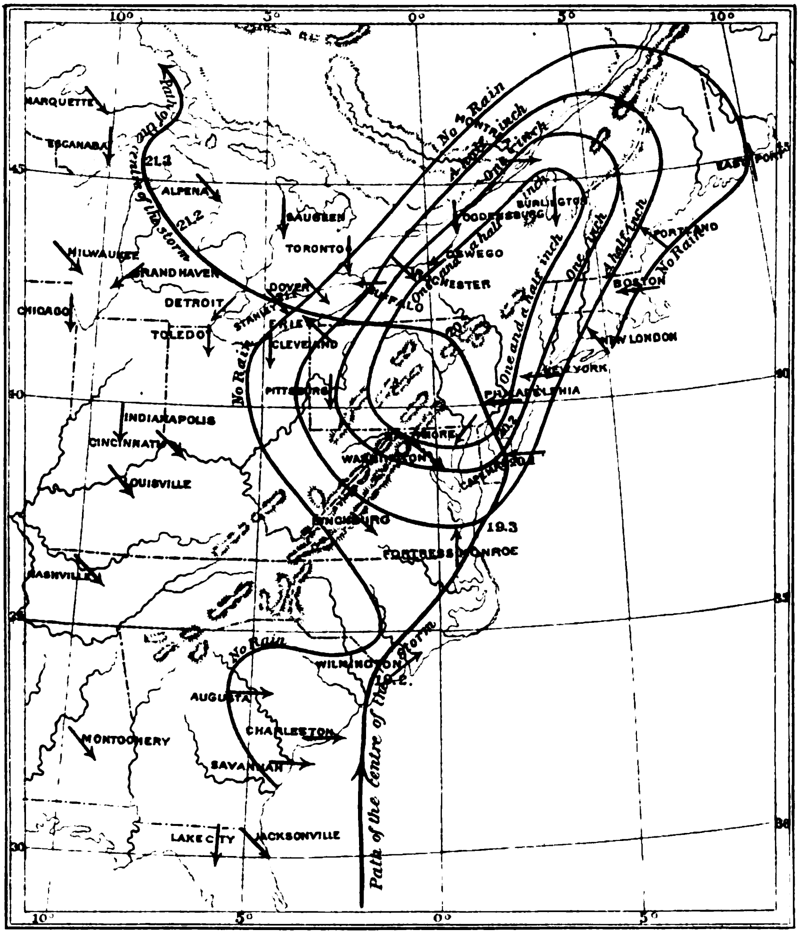
Y

Yarrow, H. C., burial customs of North American Indians, 431.

Z

Zirconia for oxy-hydrogen light, *Draper*, 208.
ZOOLOGY—
  Ant, yellow, *Leidy*, 244.
  Autography, for Natural History publications, *Sars*, 277.
  Butterflies, dimorphism in, 244.
  Cephalopod, gigantic, *Verrill*, 425.
  Challenger expedition, collections, 161.
  Colorado potato beetle, 73.
  Diagrams, 426.
  Entomological Commission, Bulletin of, 74.
  Fishes of the Bermudas, *Goode*, 289.
    new species of, *Goode* and *Bean*, 470.
  Museum, National, Bulletins, 426.
  Species, genesis of, 161.
  Teeth, human, morphology of, 323.
  Vertebrate life in America, *Marsh*, 337.
  See also under GEOLOGY.
Zulkowsky, formation of rosolic acid from cresol and phenol, 414.

RAIN AREA OCT 20. 1873. PLATE I.



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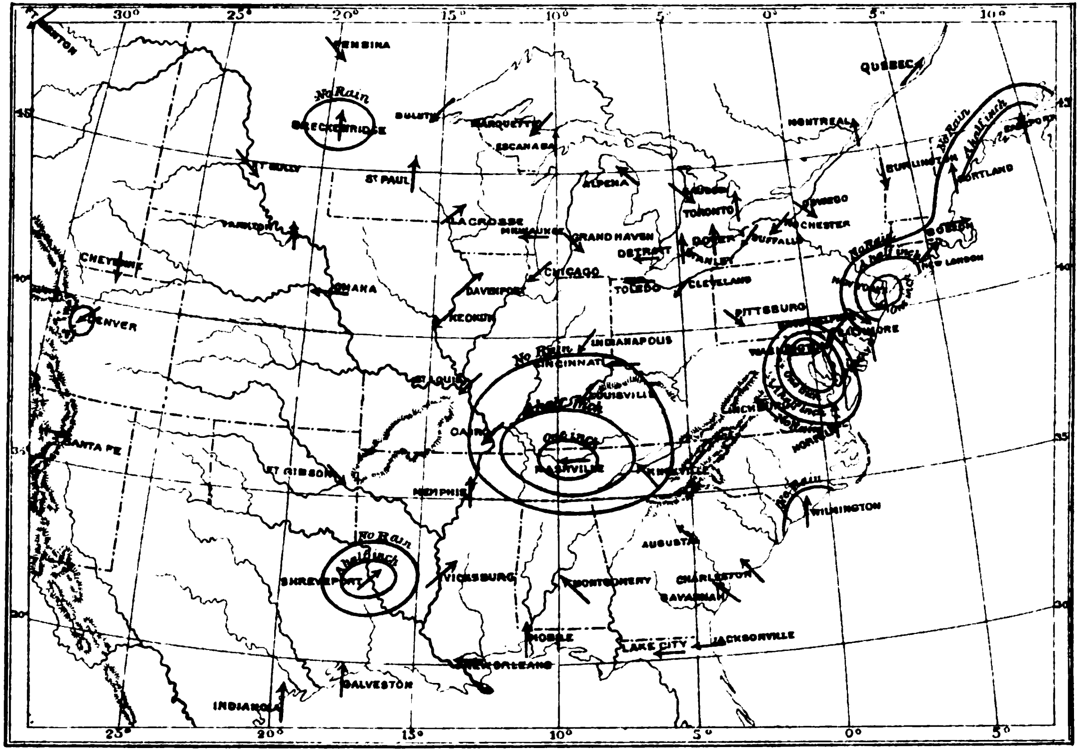
RAIN AREAS [illegible] PLATE II



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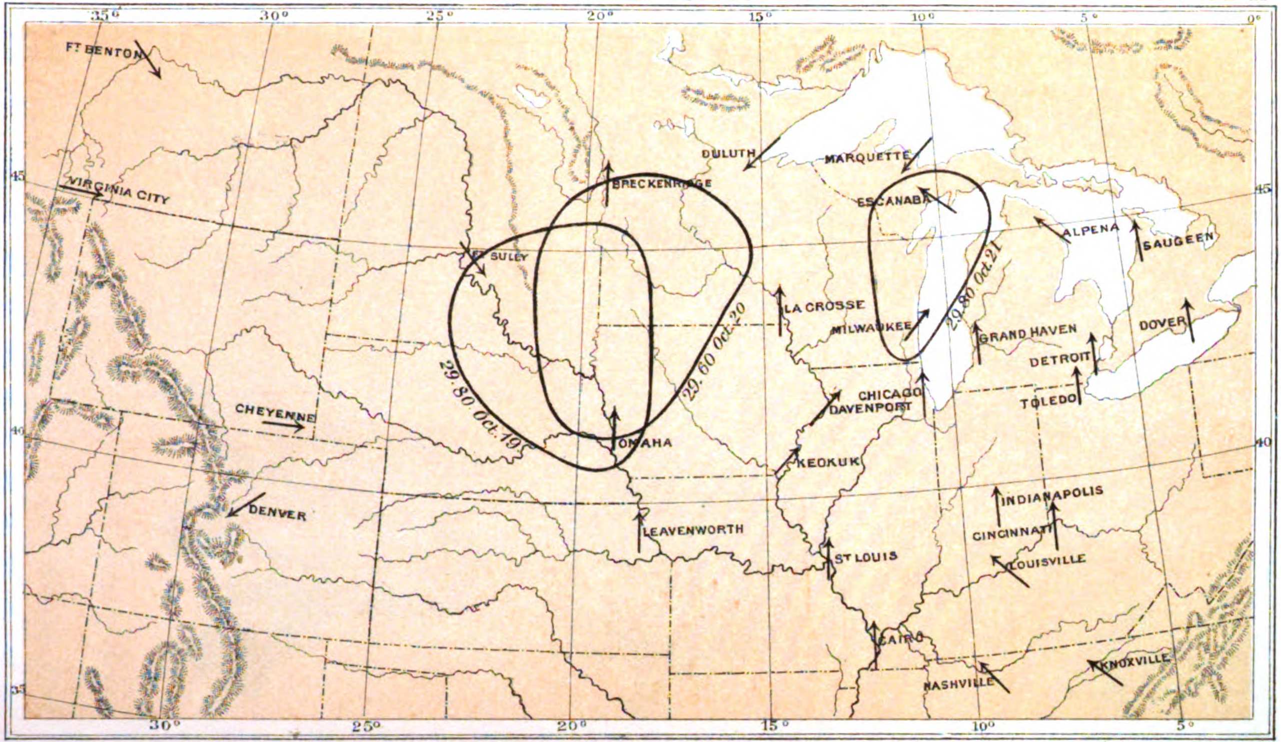

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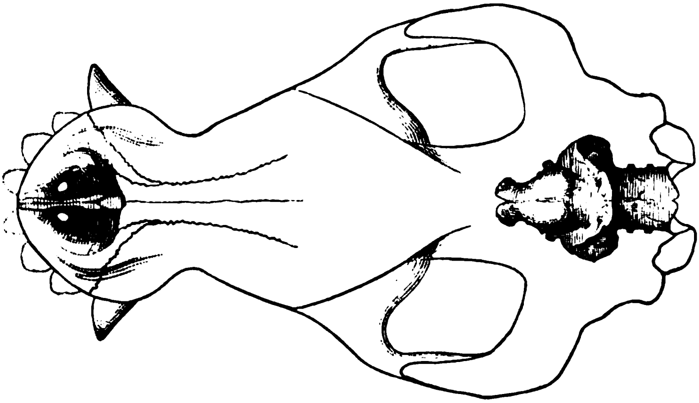

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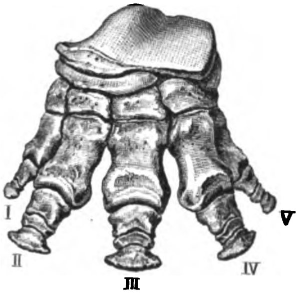

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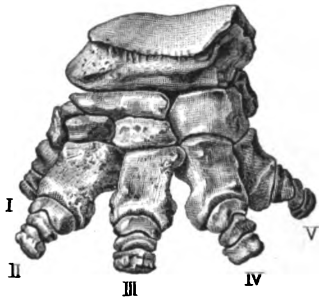

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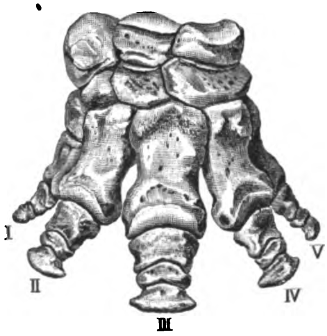

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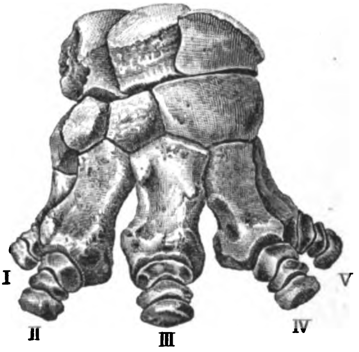

Figure 1.—Outline of skull and brain-cavity of *Coryphodon hamatus* Marsh; top view. About one-fifth natural size.
Figure 2.—Hind foot of *Coryphodon*; front view.
Figure 3.—Fore foot of *Coryphodon*; front view. Both one-third natural size.
Figure 4.—Hind foot of *Dinoceras*; front view.
Figure 5.—Fore foot of *Dinoceras*; front view. Both one-fifth natural size.

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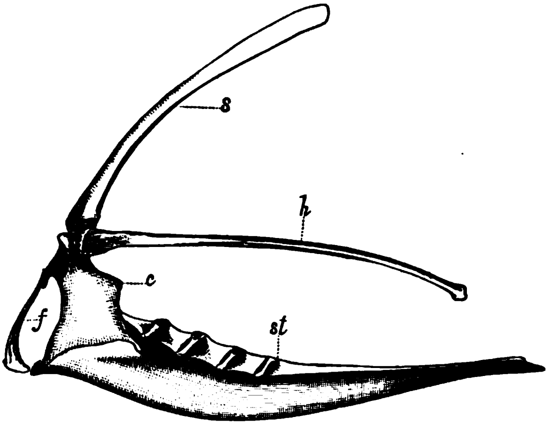

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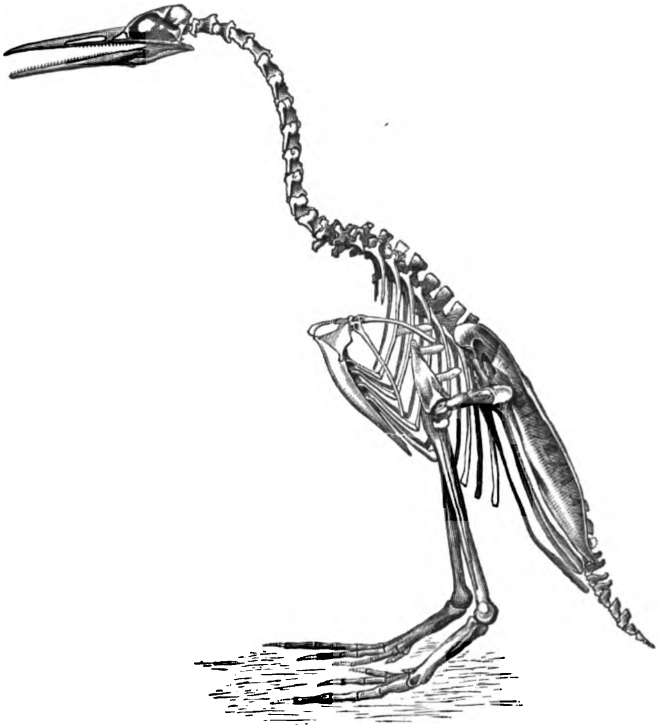

Figure 1. Scapular arch of *Hesperornis regalis* Marsh, one-half natural size. *s.* scapula; *h.* humerus; *f.* furculum; *c.* coracoid; *st* sternum.
Figure 2. Restoration of *Hesperornis regalis*, about one-tenth natural size.